DOCUMENT RESUME

ED 156 180 IR 006 206

AUTHOR Tilson, Thomas; And Others
TITLE Application of Radio to Teaching Elementary Mathematics in a Developing Country. Fifth Annual Report.
INSTITUTION Stanford Univ., Calif. Inst. for Mathematical Studies in Social Science.
SPONS AGENCY Agency for International Development (Dept. of State), Washington, D.C.
PUB DATE 1 Apr 78
CONTRACT AID/CM-ta-C-73-40
NOTE 93p.

EDRS PRICE MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS *Developing Nations; Educational Experiments; *Educational Radio; Educational Research; Elementary Education; *Elementary School Mathematics; Mathematics Instruction; Program Development; Radio; *Rural Education; Summative Evaluation; *Teaching Methods
IDENTIFIERS *Nicaragua

ABSTRACT

In 1977 the Radio Mathematics Project provided radio lessons in mathematics for 2,800 students enrolled in 105 second-grade and third-grade classes in Nicaraguan public schools. Comparisons between randomly selected experimental and traditionally taught groups show that the achievement at the end of both second and third grade was significantly higher for the experimental (radio) classes than for the traditional classes. The radio programs are being implemented on a wider scale in Nicaragua, and are being accepted well by both teachers and students. The project received international recognition when one of the second-grade programs won the Japan Prize for Radio in 1977. The feedback system of curriculum development was further refined during 1977, and a number of supplementary small research projects were completed. (Author/CMV)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED156180

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Fifth Annual Report

Agency for International Development

APPLICATION OF RADIO TO TEACHING ELEMENTARY MATHEMATICS IN A DEVELOPING COUNTRY

Thomas Tilson, Barbara Searle,

Jamesine Friend, and Patrick Suppes

with the assistance of

Alicia G. de Quintanilla, Norma Guadamuz Cermeno,
Lic. Juan Jose Montenegro Pineda, Marvin Saballos Ramirez,
John Sheehan, Vitalia R. Vrooman, and Mario Zanotti

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Barbara Searle

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

April 1, 1978

The research in this report was supported by the U.S. Agency for International Development. Department of State, Contract No. AID/CM-ta-C-73-40.

INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES

STANFORD UNIVERSITY

STANFORD, CALIFORNIA

IR006206

TABLE OF CONTENTS

		Page
INTRODUCTION		1
PROJECT CALENDAR		3
I.	SECOND-GRADE PROGRAM	5
	A. Curriculum Development	5
	B. Summative Evaluation Design	5
	C. Evaluation Results	6
II.	UNSCHEDULED VISITS	11
III.	THIRD-GRADE PROGRAM	13
	A. Introduction	13
	B. Curriculum Development	13
	C. Formative Evaluation	20
	D. Summative Evaluation	21
	E. Summary	25
IV.	CONTRACT EXTENSION	27
V.	EXPANSION OF THE PROJECT TO RIO SAN JUAN	29
VI.	PLANS FOR WIDE-SCALE IMPLEMENTATION OF PROJECT IN NICARAGUA	31
VII.	JAPAN PRIZE	35
VIII.	STAFF VISIT TO COSTA RICA	37
IX.	LISTENER SURVEY	39

X. OTHER STUDIES 41

A. Observation Study 41

B. Weekly Test Data 41

C. Analysis of Addition and Subtraction Data 41

D. Interviews with Children 41

E. Collaboration with the World Bank 42

XI. WORK PLANS FOR 1978 AND 1979 43

XII. PROJECT ADMINISTRATION 45

XIII. DISSEMINATION AND UTILIZATION OF RESEARCH RESULTS 47

XIV. INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN 51

XV. REFERENCES 53

APPENDIX

A. Performance of Third-grade Students on Posttest 55

B. Master Curriculum Plan for Third Grade 87

C. Comments on Third-grade Pretest in Relation to Third-grade Curriculum 91

INTRODUCTION

The Radio Mathematics Project was established to design, implement, and evaluate a prototype system of teaching elementary mathematics, using radio as the major medium of instruction. Since June 1974 the Institute for Mathematical Studies in the Social Sciences of Stanford University (funded by the United States Agency for International Development) and the Government of Nicaragua have been collaborating on the development of such an instructional program for use in the primary schools in Nicaragua.

In this report we summarize the work accomplished during 1977. The reporting period was changed to conform to the Nicaraguan school year. Therefore, this report overlaps the Fourth Annual Report (Searle, Friend, Suppes, & Tilson, 1977) which described the work of the project from July 1976 through June 1977. A more detailed account of the project activities during 1977 will be presented in a book (Suppes, Searle, & Friend, in preparation) to be published later this year.

On July 1, 1977 Stanford began operating under a formal continuation of its contract with AID; simultaneously a new agreement between the Ministry of Public Education and AID came into effect. In this agreement the Government of Nicaragua demonstrated its support of our work by substantially increasing its commitment to the project.

During 1977 the project broadcast daily lessons by Radio Nacional to 2,800 second- and third-grade children in 70 classrooms. The classes receiving the broadcasts were either

1. randomly selected for participation in the summative evaluation phase of the experimental work,

2. not randomly selected, but participating in the formative evaluation phase in which classes were observed several times a week and the children were tested weekly, or

3. taught by volunteer teachers.

An additional 43 classes in Grades 2 and 4 served as control classes and were pre- and posttested but did not use the radio lessons. Tables 1 and 2 show the radio and control classes by category and grade. First-grade lessons were not used during 1977 pending a decision about the use of worksheets.

The Grade 2 lessons used in 1977 were those developed during 1976 with only small modifications. The Grade 3 lessons were developed during 1977 with a complete formative evaluation process. A summative evaluation was carried out on the lessons for both grades. At each grade level the experimental classes were divided into two groups. One group (nonexperienced) contained students who had not previously used the radio lessons. The second group (experienced) contained students who had used the radio lessons for one year prior to 1977. This report presents the findings for the summative evaluations in Grades 2 and 3.

Table 1

Number of Schools, Classes, and Students Using Radio Lessons in 1977 by Grade According to Category

Category	Grade 2	Grade 3
Schools		
Experimental	39	31
Weekly Testing	0	12
Volunteer	14	14
Classes		
Experimental	40	32
Weekly Testing	0	12
Volunteer	15	16
Students	1,300	1,500

Table 2

Number of Schools, Classes, and Students Used for Control in 1977 by Grade

Category	Grade 2	Grade 4
Schools	24	19
Classes	24	19
Students	544	283

Note. Grade 3 control was tested in 1976.

The report also describes briefly several other studies and activities undertaken by the project during 1977. These activities are not covered in detail here because they will all be treated in the forthcoming book (Suppes et al., 1978).

PROJECT CALENDAR

January 1, 1977 to December 31, 1977

January 24 - 26	Field visit, sponsored by EDUTEL, for economic study of the project.
February 15 - 19	Teacher training, 1 session each for participating teachers in Masaya, Granada, and Carazo.
February 28	Lesson 1 broadcast by Radio Nacional to 55 second-grade classes and 60 third-grade classes.
February 28 - March 17	Pretests administered to 18 second-grade, 36 third-grade and 24 fourth-grade classes.
March 1	Japan Prize awarded to the Radio Mathematics Project for Lesson 171, second grade.
March 10	AID Review meeting in Washington, D.C.
April	Forms sent to teachers for student data collection.
June 22	AID and Ministry sign new contract to extend project.
July 1	Continuation contract starting date
July	Children interviewed on working subtraction exercises
September	Visit to Rio San Juan to plan for 1978 implementation
September 28 - October 14	Unannounced visits to schools using radio lessons
November	Listener survey carried out
November 9	End of posttesting Grades 2, 3 and 4
November 18	Lesson 164 broadcast to Grades 2 and 3
December 10 - 13	Staff members visit Instituto Costarricense de Ensenanza Radiofonica (ICER)
December	MEP purchases 43 radios with money received from Japan Prize

I. SECOND-GRADE PROGRAM

A. Curriculum Development

The curriculum for Grade 2 was developed during the 1976 school year using the formative evaluation methods that have since become standard for the project. The formative evaluation procedure used data collected from weekly achievement tests and daily classroom observations to modify the subsequent lessons. This was the first year that weekly tests were administered for the entire year and thus constituted a test of that procedure. The methods, used again in 1977, are described below.

The Grade 2 curriculum was based as closely as we felt possible on the curriculum specifications of the Ministry of Public Education. Further discussion of the curriculum can be found in the Fourth Annual Report (Searle et al., 1977, pp. 42-54).

B. Summative Evaluation Design

A preliminary summative evaluation was carried out on the second-grade curriculum in 1976 using randomly selected control classes, but volunteer experimental classes. The results from this study, reported in the Fourth Annual Report (Searle et al., 1977, pp. 54-57), were not conclusive because of the nonrandom selection of the radio classes, and an error made in distributing the posttest forms to the classrooms.

The formal summative evaluation was conducted in 1977. The experimental group was comprised of two sets of classes, all of which were selected at random: 18 classes (posttest data were not collected for one of these classes) whose students had no previous experience with the radio lessons--the nonexperienced students; and 24 classes (posttest data were not collected for two of these classes) whose students were part of the Grade 1 experimental group during the preceding year--the experienced students. Thus, the design enables us to assess the cumulative effects of the radio lessons.

Twenty-four control classes were selected at random. The experimental and control classes were each distributed equally among the departments of Masaya, Granada and Carazo, and between urban and rural schools.

The nonexperienced experimental group was pretested and posttested in 1977. The experienced experimental group was posttested in 1977; they were not pretested because of other demands on the project resources. The control group was also posttested but not pretested in 1977.[1] Because the experimental and control classes were all selected

---

[1]The error in test distribution, which invalidated the results of the 1976 tests, was discovered too late to indicate the need for pretesting another second-grade control group.

at random it is appropriate to make a posttest-only comparison and we present these results in the next section.

C. Evaluation Results

As can be seen in Table 3, which presents the posttest results for 1977, the mean score for the experimental group, 82.9, is significantly higher than that for the control group, 74.2. The table also presents results separately for the two experimental groups, experienced and nonexperienced. The students with two years of radio experience scored significantly higher than those with no previous experience and outscored the control group by more than ten points.

Table 3

Performance of Experimental and Control Groups on 1977 Second-grade Posttest

Group	N	Estimated mean score[a]	Standard error	95% confidence interval
Experimental, total	783	82.9	.35	82.2 - 83.6
Nonexperienced	300	78.6	.50	77.6 - 79.6
Experienced	483	85.6	.40	84.8 - 86.4
Control	542	74.2	.40	73.4 - 75.0

[a]Maximum score: 125

The reader will recall that the project uses a matrix-sampling design for all its tests. The scores presented in Table 3 are estimated using procedures described fully by Wagner (forthcoming book, Suppes et al., in preparation) in which the group mean is estimated for the hypothetical situation in which every examinee takes every item. In fact, each examinee took only one-fifth of the items. Following Wagner (who built on work by Sirotnik, 1974), the 95% confidence intervals are used to examine statistical significance. The confidence interval can be interpreted as follows: A mean score that falls outside the 95% confidence interval of another score has only one chance in 20 of being the mean of a sample drawn from the same population. In Table 3 each mean differs significantly at the 5% level from all the others. Thus, the mean score for the experienced group is significantly higher than that for the nonexperienced group which in turn is significantly higher than that of the control group.

Test results are reported for individual items in Appendix A. Table A in the appendix compares the experimental and control groups,

Table B the two levels of experience. We present a summary comparison of performance of the experimental and control groups by mathematical topic in Table 4. (Note that this table reports mean percentage correct.) The experimental students scored higher than control students on 15 of the 18 topics tested; differences range from 1.0 to 17.8 percentage points. Topics with the greatest difference are vertical subtraction (17.8), vertical addition (17.0), horizontal subtraction (14.2), and fractions (10.9). The control group performed substantially better than the experimental group only on geometry (14.6). This topic, along with measurement, on which the control classes scored 2.7 points higher, was not taught by the radio lessons, but was left to the classroom teacher to present.

The radio lessons placed the greatest emphasis on addition and subtraction, particularly in the written vertical form. In these areas the students in the experimental classes showed the most outstanding gains relative to the students in the control classes.

The project also expended considerable effort on fractions. Special visuals were prepared (the only support material developed for second grade) for use during the radio lessons. The experimental classes scored substantially better on this topic than the traditional classes.

Finally, it is not surprising to find, given the audio presentation of radio, that the students in experimental classes performed better than those in control classes on all oral topics. The range in difference was from 2.8 to 7.9 points.

Table 5 presents a similar comparison between the nonexperienced and experienced radio students. The experienced students scored higher on 17 of the 18 test topics, with the difference in mean topic score ranging from 1.9 to 25.0 percentage points. The experienced students scored substantially higher on time (25.0), oral subtraction (14.5), measurement (13.8), oral multiplication (12.3), and fractions (8.7). These findings are consistent with the instructional experience of students who used the first-grade lessons. The first-grade lessons gave heavier emphasis to the topics of time, measurement, and fractions than did the second-grade lessons; apparently these students remembered what they learned in first grade. The performance difference in subtraction may be explained by two factors--the difficulty of the subtraction concept and the stress in the first-grade lessons. One can contrast subtraction with addition, which is much easier. Although the experienced students did better in oral addition than the non-experienced, the difference is smaller probably because the addition concept is easier for the students to learn.

The results for oral multiplication provide an interesting case. The experienced children may have had greater success with oral multiplication because of the stress given to understanding the meaning of addition in first grade, since the concept of repeated addition was used to teach multiplication in second grade.

The nonexperienced students outscored the experienced students on only one topic, oral division (7.1). We have no hypothesis to account for this outcome.

Table 4

Comparison of 1977 Second-grade Posttest Scores of Experimental and Control Students by Topic

Topic	Number of items	Mean percentage correct		
		Experimental	Control	Difference
Numeration	25	79.4	78.3	1.1
Basic Concepts	5	41.3	39.9	1.4
Oral Addition	5	80.8	75.9	4.9
Vertical Addition	10	72.9	55.9	17.0
Horizontal Addition	5	71.4	65.6	5.8
Oral Subtraction	5	75.7	67.8	7.9
Vertical Subtraction	10	52.5	34.7	17.8
Horizontal Subtraction	5	65.8	51.6	14.2
Fractions	10	58.5	47.6	10.9
Money	5	48.8	46.0	2.8
Oral Multiplication	3	84.8	82.0	2.8
Vertical Multiplication	5	64.4	58.6	5.8
Oral Division	2	56.6	48.7	7.9
Vertical Division	5	63.3	56.7	6.6
Time	5	47.8	46.8	1.0
Geometry	2	64.7	79.3	-14.6
Measurement	3	26.4	29.1	-2.7
Word Problems	15	66.3	66.3	0.0

Table 5

Comparison of 1977 Second-grade Posttest Scores of Experienced and Nonexperienced Students by Topic

Topic	Number of items	Mean percentage correct		Difference
		Nonexperienced students	Experienced students	
Numeration	25	78.1	80.3	2.2
Basic Concepts	5	39.2	43.4	4.2
Oral Addition	5	77.4	83.3	5.9
Vertical Addition	10	71.4	74.0	2.6
Horizontal Addition	5	70.1	72.6	2.5
Oral Subtraction	5	67.1	81.6	14.5
Vertical Subtraction	10	49.8	54.5	4.7
Horizontal Subtraction	5	64.1	66.7	2.6
Fractions	10	53.2	61.9	8.7
Money	5	46.2	51.0	4.8
Oral Multiplication	3	76.7	89.0	12.3
Vertical Multiplication	5	60.1	67.4	7.3
Oral Division	2	61.3	54.2	-7.1
Vertical Division	5	59.8	66.7	6.9
Time	5	33.2	58.2	25.0
Geometry	2	63.8	65.7	1.9
Measurement	3	18.4	32.2	13.8
Word Problems	15	64.5	67.4	2.9

In conclusion we see that for almost all topics taught by the radio lessons the experimental students performed better than the control students and the experienced students performed better than the nonexperienced students.

Looking at Tables 4 and 5 together one notices that the nonexperienced students scored within about a point of the control group students on 4 of the 18 topics and lower than the control students on five other topics, some not taught by radio. Thus, the performance differences between nonexperienced second-graders and those taught by traditional methods are not nearly as great as those found at the first-grade level. However, there is a clear cumulative effect and experienced students substantially outperform traditional students on almost all topics.

II. UNSCHEDULED VISITS

To determine how many of the radio classes might not be listening to the broadcasts on a regular basis (that is, most of the time), project staff members made unannounced visits to 23 second- and third-grade classes during the period from September 28 to October 14. The visitors arrived during the mathematics period, when it was expected that the radio would be turned on. They found this to be the case in 14 of the 23 classes. In each class they talked to the teachers and children about use of the radio lessons. As a result of these conversations they concluded that an additional six classes used the lessons regularly (although clearly not every day).

The level of usage appeared to be higher in the urban schools than in rural schools. Of the ten urban classes visited, the radio was being used in seven. Of the remaining three classes, two apparently listened to the broadcasts regularly, but had a special examination on the day of the visit. The last class reported that the radio had been stolen several months previously.

In the rural schools, the radio was being used in only 7 of the 13 classes visited. However, in two classes the teacher was absent but the children reported they listened to the lessons regularly. Two teachers reported that their radios had been stolen just a few days prior to the visit. In the remaining two classes, the teachers had stopped using the broadcast about a month previous to the visit. No clear reasons were given.

In short, we found the teacher present and using the radio on the day of the visit in 61% of the classes. However, it appears likely that 87% of these classes use the broadcasts on a regular basis.

In general the teachers using the radio lessons appeared satisfied with the program and reported few problems. Problems that were reported included: the radio was broken down in one school; two teachers said the children found the end of third grade boring; similarly one second-grade teacher said her older children (ages 12 and 13) were sometimes bored; and several teacher complained about occasional program interruptions by Radio Nacional for special broadcasts of national interest.

III. THIRD-GRADE PROGRAM

A. Introduction

The basic format of the third-grade lessons is similar to that of the earlier grades. The lesson consists of two parts, a half-hour broadcast and a 20-minute post-broadcast period in which activities are presented by the classroom teacher based on a teacher's guide prepared by the project. The broadcasts are divided into many segments each lasting approximately two to three minutes and each on a different mathematical theme; interspersed among these segments are brief entertainment presentations, such as songs, games or jokes, some of which also have mathematics content.

The third grade differs from earlier grades in its use of support materials. The trend through the grades has been to reduce the level of support materials used. For first-grade lessons, worksheets produced by the project are distributed to children. Because of its high cost this practice has not been continued in later grades. For the second-grade lessons, the project requires the classroom teacher to write exercises on the blackboard prior to the broadcast; the radio characters refer to these exercises during the lessons. For the third-grade lessons, no exercises are written on the blackboard; all exercises are dictated by the radio characters to the children during the course of the broadcasts.

The primary reason for discontinuing the practice of having the teacher write on the blackboard was to make the programs less dependent on the classroom teacher. We foresaw several advantages. First, it would free the teacher to spend more time teaching, either the third-grade children, or those in other grades in the same classroom. Second, the program, by relying less on a classroom teacher, could be used in a greater variety of situations not initially anticipated by the project, for example, where a classroom monitor, rather than a qualified teacher, was present. Another advantage was that children (or adults) could listen at home. The major disadvantage to dictating exercises was the broadcast time consumed. We were concerned also that teachers might not feel comfortable about further diminishing their role.

The project staff members decided to begin the year using dictation and to review this decision thoroughly during the early part of the year. After careful review on two different occasions, it was agreed overwhelmingly that the lessons were going well and the practice should be continued. We observed many situations where the teacher did, in fact, use the broadcast time to instruct children at a different grade level and we received no complaints from the teachers about the procedure.

B. Curriculum Development

The process for developing the third-grade curriculum was similar to that undertaken for the earlier grades, although the

procedure was more refined and carried out in more detail. The full curriculum for the third grade will be published separately in a forthcoming book (Suppes et al., in preparation). An outline of the curriculum development procedure, however, follows.

The broad outlines for the curriculum were obtained from the curriculum guide prepared by the Ministry of Public Education. Table 6 presents an outline of the guide and shows the time allotted to each topic in weeks and as a percentage of the school year. Before adapting the Ministry guide to the radio instructional program we examined the results of the pretest given to students in third-grade traditional classes in 1976 (the previous year). The full report of the test results and the implications for curriculum development are presented as Appendix B. The test identified areas of strength and weakness and suggested modifications of both topics and time allocations. As a result, the initial plan for the radio curriculum, shown in Table 7, gave more weight to the four fundamental operations than did the Ministry curriculum and much less to the new topic of decimals. The planned radio curriculum also reduced the emphasis on measurement and geometry. The topic of sets, which appears in the Ministry curriculum, is not taught separately by the radio curriculum but is incorporated into the topics of numeration, addition, and subtraction where appropriate. Table 7 also presents the actual allocation of exercises among topics, which differs quite markedly from the plans. This point will be discussed below.

Table 6

Allocation of Third-grade Curriculum Topics, Ministry of Education Guide

Topic	Weeks	Percentage
Exploration	1	3
Sets	3	9
Numeration	3	9
Addition and subtraction	4	12
Multiplication and division	3	9
Fractions	3	9
Decimals	6	18
Money	2	6
Measurement	4	12
Geometry	5	15

Table 7

Allocation of Third-grade Curriculum Topics,
Radio Instructional Program

Topic	Planned		Actual	
	Number of exercises	%	Number of exercises	%
Numeration	516	7	1,261	18
Addition	748	9	911	13
Subtraction	1,338	17	1,465	21
Multiplication	1,520	19	1,381	20
Division	1,520	19	922	13
Mixed Operations	80	1	0	0
Fractions	794	10	763	11
Decimals	444	6	331	5
Word Problems	640	8	0	0
Measurement	240	3	0	0
Geometry	160	2	26	<1
Total	8,000		7,060	

In planning the curriculum, major topics were subdivided into subtopics or "strands." These are listed in Table 8. Once the allocation of curriculum materials to strands was made, the curriculum development work could proceed at a more detailed level. First, each strand was divided into "exercise classes" which ranged in number from 5 to 31 classes for a strand. Second, each exercise class was precisely described. Third, the prerequisite learning skills were determined for each class.

In general, "prerequisite" is defined as follows. Class A is said to be prerequisite to Class B if Class A must be taught first in time. This rather weak relationship is strengthened in the case of a "key" prerequisite. If Class A is a key prerequisite of Class B then Class A must not only be taught first, but also must be "mastered." Mastery is defined in terms of proportion correct on test items and the exact level of mastery is dependent upon the characters of both A and B. (For further discussion see p. 45-46 of Fourth Annual Report, Searle et al., 1977.)

Table 8

Strands Comprising Third-grade Radio Curriculum

Topic		Strand
Numeration	NE	Whole numbers
	NC	Counting numbers
	NO	Ordinals
	NS	Sequences
	NF	Fractions
	ND	Decimals
	CE	Comparison of whole numbers
	CF	Comparison of fractions and mixed numbers
	CD	Comparison of decimals
Addition	AO	Oral addition
	AH	Horizontal addition
	AV	Vertical addition
	AF	Addition of fractions
Subtraction	SO	Oral subtraction
	SH	Horizontal subtraction
	SV	Vertical subtraction
	SF	Subtraction of fractions
Multiplication	MO	Oral multiplication
	MH	Horizontal multiplication
	MV	Vertical multiplication
Division	DO	Oral division
	DV	Vertical division
Geometry	GE	Area

Table 9, an example of the tables prepared for each of the strands, presents the exact description and prerequisites of the eight classes comprising the horizontal subtraction strand. For example, it shows that SH1 is limited to exercises of the type M-b (where M is less than or equal to 10), and that SO1, the first class of the oral subtraction strand, is a prerequisite.

The next procedure was to string the various prerequisites together within each strand. Figure 1 shows in diagrammatic form the sequence of instruction for horizontal subtraction. It shows that for a child to learn to perform subtractions of the type a00-1 (SH5), prior instruction must include the classes SO7 and SH4. SH4 in turn, requires SO6 and SH3. SH3, in turn, must be preceded by SO4 and SH1, which must be preceded by SO1.

Once the sequence of instruction was determined for each strand, the various strands were woven together to create the total curriculum

Table 9

Definition of Exercise Classes of Horizontal Subtraction Strand

Class identifier	Description[a]	Prerequisites
SH1	M - b (M<11)	SO1
SH2	M - b (10<M<19)	SO2, SH1
SH3	a0 - 1	SO4, SH1
SH4	ab0 - 1	SO6, SH3
SH5	a00 - 1	SO7, SH4
SH6	ab - c (c<=b)	SO8, SH1
SH7	ab - a0	SO9, SH1
SH8	ab - cd (d<=b)	SO10, AH6, SH7

[a]A lower case letter represents one of the digits 0,1,2,3,4,5,6,7,8,9. "a0" is a multiple of 10, "a00" a multiple of 100. "a" appearing twice in the same exercise represents the same number.

for the year. This process was considerably more complex than determining the sequence for just one strand. The initial master curriculum plan for third grade can be found in Appendix C. The plan shows the week of introduction for each exercise class in the curriculum. For example, for horizontal subtraction, SH1 appears in week 4, SH2 in week 5, SH3 in week 13, SH4 in week 18, SH5 in week 19, SH6 in week 22, SH7 in week 23 and SH8 in week 24. These times of introduction are chosen so that all prerequisite relations are satisfied. This plan guided the preparation of lessons throughout the year except where information gathered from the classrooms indicated the need for change.

At the next level of detail, an outline was prepared for each of the lessons constituting a week's work. Figure 2 shows the outline for Lesson 16, the first lesson of week 4. Each outline divides the lesson into a number of segments, in this case, seven. For each segment the following information is given: the mathematical class or classes; any materials to be used; the kind of answer required of the students (i.e.. oral, delayed oral, written, etc.); and a description for each class along with all the specific examples. The outline was then passed to the script writers who prepared the instructional dialogue and recorded using professional artists and, shortly thereafter, broadcast to the schools.

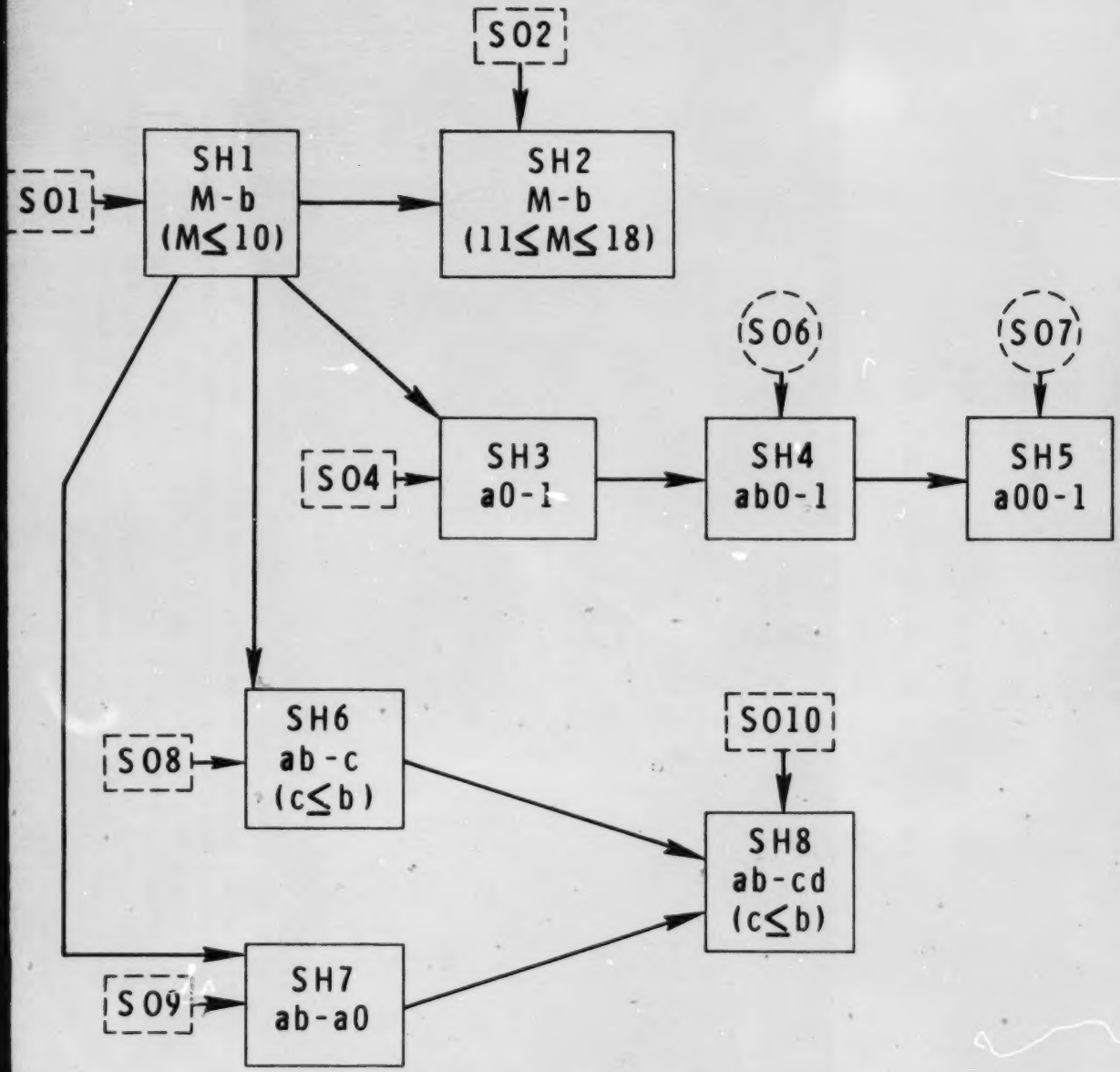

Figure 1. Structure of Horizontal Subtraction Strand.

Third Grade Lesson 16 Version 1 Date 2/23/77

Segment	Class	Presentation	Materials	Response	Exercise Description
1	S01-5	Radio		Oral,	Oral subtraction, m-b ($m \leq 10$), with counting
	S02-2			delayed	Oral subtraction, m-b ($11 \leq m \leq 10$), with counting
					(8-6, 12-9, 24-8, 11-5)
2	NF5-1			Oral	Mixed fractions, $a\frac{b}{c}$ ($b \leq c$), concept and vocabulary
					($2\frac{1}{2}$, $3\frac{1}{4}$, $1\frac{2}{3}$)
3	S04-1	Radio		Oral, delayed	Oral subtraction, a0-1
					(10-1, 20-1, 30-1, 40-1, 50-1, 60-1, 70-1, 80-1, 90-1)
4	GE1-1	Radio	Graph paper notebook*	Drawing	Concept of area
5	AV2-3	Homework	Graph paper notebook	Written exercise	Vertical addition, 3 columns, no passing
	AV1-5				Vertical addition, ab+cd ($a+c \leq 10$), 2 columns, with passing
	SV2-3				Vertical subtraction, 3 columns
					(32+90, 695-155, 84+64, 778-433, 720+230, 972-551)
6	AH1-1	Teacher	Graph paper notebook	Written exercise	Horizontal addition, a+b
	SV1-1				Horizontal subtraction, m-b ($m \leq 10$)
					(6+1, 8-3, 1+1, 7-3, 9+4, 2-1, 9-4, 9-5)
7	S04-2	Teacher	Graph paper notebook	Written exercise	Oral subtraction, a0-1
					(20-1, 40-1, 50-1, 30-1, 60-1, 80-1, 70-1)

*Standard notebooks used by children.

Figure 2. Outline for Lesson 16.

It should be emphasized that the development of the curriculum is a flexible process. At the beginning of the year final objectives and broad outlines are developed, but the content of specific lessons is not finally decided upon until a few weeks prior to the actual broadcast. This flexibility allows achievement data collected weekly, and findings based on daily classroom observations, to be incorporated into the subsequent lessons. For example, if the children learned a theme more quickly than expected, future lessons would present less material on that theme; on the other hand, should they experience more difficulty than expected, subsequent lessons would incorporate more material on that subject than originally anticipated. The extent of the changes actually made in the third-grade curriculum can be seen by comparing the two columns of Table 7. The changes included dropping some topics from the radio curriculum (although not necessarily from the postbroadcast portion of the lesson) in order to give more instruction and practice in topics, such as numeration, addition, and subtraction, that were considered to be more fundamental. The changes were, in most cases, dictated by the results of data collected as part of the formative evaluation process described in the next section.

C. Formative Evaluation

The formative evaluation for the third-grade curriculum was similar to that carried out for Grades 1 and 2. The basic purpose of the evaluation was to collect data about the lessons throughout the year, and to use this information to modify the forthcoming lessons. Two types of data were collected: results of achievements tests administered to children every week; and classroom observations made by project staff members on a daily basis.

Observation and test data were collected from 12 classrooms whose teachers volunteered to participate in the program. (These classes were not part of the randomly selected experimental group.) Equal numbers of urban and rural schools were selected, and all schools were located within a 30-minute drive from the project office.

Classroom observations provide valuable feedback on how the lessons are being received and understood. They generally give the observer a more direct and intuitive understanding of what is happening in the classroom than can be obtained from performance data. Project staff members visited an average of three classes daily. During the lesson the observers made notes on specially prepared observation sheets--a separate and distinct sheet for each lesson. A summary of the notes from the different observers was prepared each day; this was passed on to the curriculum developers and script writers.

Weekly tests were administered to all 12 classes starting with the sixth week. (A more detailed description of the weekly testing program will be included in the forthcoming project book, Suppes et al., in preparation.) An attempt was made to test each class on the same day of the week. The tests, which took about 20 minutes, were administered by a project staff member.

The tests used a multiple matrix sampling design (which has been described in an earlier project publication, Searle, Friend, & Suppes, 1976). The major advantage of this type of test is that many items can be tested, even though each child receives only a fraction of the total number of exercises. For example, for the test given during Week 19, 123 items were tested, yet each child was presented with only 24 exercises. (These tests had a rather complex design; in order to minimize the effect of differences among classrooms, "group" items--those presented to an entire class--were given to twice as many children as "individual" items. The test referred to here had 102 individual items and 21 group items.)

Tests were hand-graded and the results were passed on to the curriculum developers within two or three days. These data, together with information from the classroom observations, were then analyzed in terms of how student performance compared with the expected level. Future lessons were then modified according to the interpretation of these data. When performance on key prerequisite exercises classes fell below an acceptable level the master plan was modified to delay instruction in all topics that depended on that prerequisite.

In general, observation data lead to changes in the entertainment, presentations, in the writing of instructions, and the rate at which children are expected to respond. On the other hand, test results lead to changes in the lesson outlines and, occasionally, in the master plan.

The process of data interpretation and lesson modification is described in Friend (1976).

D. Summative Evaluation

The process of lesson development had reached a high level of sophistication by 1977; thus, the project decided it could undertake two phases of work in the same year and conduct the summative evaluation of the third-grade instructional program during the year that the program was being developed.

The basic comparison for the third-grade summative evaluation is between an experimental group of 24 classes without prior radio experience and a control group of 24 classes. Both these groups were pretested and posttested. The testing for the control group was done during the 1976 school year. There were two reasons for this decision: to avoid contamination from control-group students listening to radio lessons (the third-grade lessons had not yet been developed in 1976) and to obtain data for use in curriculum development, as described above.

For both the control and experimental groups eight classes were chosen from each of the three departments associated with the project--Masaya, Granada, and Carazo--and of the eight, five were in rural schools, three in urban schools. (The ratio of five rural to three urban schools was adopted because class sizes are smaller in rural areas.) The procedure for randomly assigning schools to treatment condition and then randomly selecting classes within schools was described in the Fourth

Annual Report (Searle et al., 1977). The comparison we report is between randomly selected classrooms stratified by school location (rural/urban) and department.

Table 10 presents pretest and posttest results for the experimental and control groups. (The reader is reminded that the two tests were different and thus mean scores can only be compared within tests. However, the two tests had a common set of items and for these items it is appropriate to look at gains, as will be done below.) The experimental and control classes do not differ on the pretest; on the posttest the experimental group mean is significantly higher than that of the control group. Thus, as with the first-grade and second-grade programs, students using the radio mathematics instructional program scored significantly higher than students in traditional classes on a mathematics achievement test.

Table 10

Comparison of Third-grade Experimental and Control Groups

	Control group	Experimental group
Pretest		
Number of students	547	467
Estimated mean score	77.3	76.3
95% confidence interval	76.5 - 78.1	75.5 - 77.1
Posttest		
Number of student	459	418
Estimated mean score	56.0	67.4
95% confidence interval	55.3 - 56.7	66.5 - 68.3

Individual item scores for both experimental and control groups are presented in Table C of Appendix A; they are summarized by topic in Table 11. The experimental students outscored the control students in almost all topics and showed the largest difference for decimals, subtraction, and addition. One might explain the higher level of performance on addition and subtraction by the greater emphasis given to these topics in the radio curriculum as compared with the traditional program (see Tables 6 and 7). However, the topic of decimals was given much lighter treatment by the radio math program (5% as compared with 18% for the Ministry guide) and we feel confident in attributing the higher performance level in this topic to more effective instructional strategies.

Table 11

Comparison of Third-grade Posttest Scores of Experimental and Control Students by Topic

Topic	Number of items	Mean percentage correct		
		Experimental	Control	Difference
Numeration	15	62.7	57.6	5.1
Addition	15	74.6	61.2	13.4
Subtraction	12	67.7	47.8	19.9
Multiplication	14	48.6	38.7	9.9
Division	10	48.6	50.0	-1.4
Fractions	19	44.5	35.0	9.5
Decimals	14	43.0	20.7	22.3
Word Problems	15	56.0	51.9	4.1
Measurement	10	44.1	43.7	0.4
Geometry	4	5.3	4.5	0.8

Note. Control students were tested in 1976, experimental students in 1977.

The third-grade pretest and posttest had 28 items in common and for these we can compare gain in student performance for students in radio and traditional classes. The results for individual items are shown as Table E in Appendix A; they are summarized by topic in Table 12. The students in traditional classes (control) gained an average of 14.6 points on these items; the comparable gain for radio students was 24.0 points. The strongest gain for both groups was for items on fractions, for which the pretest score was very low. Neither group seems to have learned much about measurement.

Two other groups of third-grade students were posttested, eight classes who used the radio mathematics lessons in second grade (the experienced group) and 12 classes that were used during the year for weekly testing and classroom observations (the observed group). The classes comprising the experienced group are a subset of the randomly selected 1976 experimental group. They were not pretested. The observed group was not randomly selected and scored significantly higher

Table 12

Comparison of Third-grade Pretest and Posttest Scores on Identical Items for Experimental and Control Students by Topic

Topic	Number of items	Mean % correct pretest	Control mean gain	Experimental mean gain
Numeration	7	62.2	10.2	15.7
Addition	5	57.8	7.8	17.2
Subtraction	5	50.2	9.6	24.9
Multiplication	1	64.8	19.0	18.1
Division	3	47.9	21.8	32.9
Fractions	5	26.9	31.1	43.3
Measurement	2	30.0	5.4	4.5
Total	28	49.2	14.6	24.0

on the pretest (mean score 85.3) than the control group. Table 13 presents the posttest results for these groups and compares them with test results for the experimental and control groups. The mean score for each group differs significantly from all the others. The highest score was obtained by the observed group; in fact, this group scored about 50% higher than the control group. (The reader should recall that this group also scored higher on the pretest than the control group.) These students appear to be the beneficiaries of a considerably higher level of attention from the project staff. The next highest score was obtained by the students with previous experience with radio math.

Table 13

Summary of 1977 Third-grade Posttest Results

Group	N	Estimated mean	Standard error	Confidence interval
Control	459	56.0	.35	55.3 - 56.7
Experimental	418	67.4	.45	66.5 - 68.3
Experienced	173	73.0	.55	72.9 - 74.1
Observed	242	79.5	.45	78.6 - 80.4

The item scores for these two groups--observed and experienced--are presented in Table D of Appendix A and summarized in Table 14, where the scores for the experimental group are repeated for comparison. It is interesting to note that experience confers the greatest advantage in the topic of decimals, one which is new in third grade but which depends very heavily on concepts of numeration and skills of addition and subtraction that were taught in second grade. As we noted above, decimals is a topic on which students in traditional classes do very poorly.

Table 14

Comparison of Third-grade Posttest Scores of Observed, Experienced, and Experimental Students by Topic

Topic	Number of items	Mean percentage correct		
		Observed	Experienced	Experimental
Numeration	15	66.1	64.9	62.7
Addition	15	84.5	79.6	74.6
Subtraction	12	78.9	73.4	67.7
Multiplication	14	59.5	45.5	48.6
Division	10	60.8	56.6	48.6
Fractions	19	52.0	50.0	44.5
Decimals	14	54.3	54.9	43.0
Word Problems	15	64.4	55.4	56.0
Measurement	10	52.9	43.5	44.1
Geometry	4	7.4	8.1	5.3

E. Summary

As this brief resume of the curriculum development and testing work of the project's third year in Nicaragua indicates, we have developed an effective method for producing and evaluating a full year of mathematics curriculum in one calendar year and that curriculum, consisting of a set of 170 radio lessons and associated teacher's guides, produces higher achievement levels than the traditional instructional program. As with all earlier experimental comparisons, the project staff did not supervise implementation in the field. The results of the unscheduled visits described earlier indicate that not all teachers used the program regularly. We do not have sufficient information to make a

reliable estimate of usage for each class. Such an analysis of the 1976 first-grade experiment indicated that test scores for high users were higher than for low users and we would expect the same result to hold for third grade. Thus, we would expect that a more systematic program for insuring usage by teachers would show even higher achievement scores than were demonstrated here. In short, we think the radio mathematics lessons are a robust treatment that can be counted on in a wide variety of settings to produce higher levels of student achievement than traditional instructional programs.

IV. CONTRACT EXTENSION

New agreements were reached in 1977 extending the project to 1979. The extension of the project is important, not only for the additional work that will be accomplished, but because the new obligations of the government of Nicaragua underscore their strong support of the effort.

The extension of the project required two new agreements starting July 1, 1977, one between IMSSS and AID, and the other between the MEP and AID. The new contract between IMSSS and AID allows for continued Stanford support in Nicaragua through 1978; the remaining period of the contract, which terminates on June 30, 1979, allows for consulting in Nicaragua, and data analyses and final report writing at Stanford. The agreement between AID and the MEP terminates December 31, 1978.

The major work to be carried out under the project extension is:

1. In 1977

    a. complete curriculum development for Grade 3
    b. continue broadcasting lessons for Grades 2 and 3
    c. complete summative evaluation for Grade 2

2. In 1978

    a. develop curriculum for Grade 4
    b. revise curriculum for Grade 1
    c. broadcast lessons for Grades 1 through 4
    d. carry out summative evaluation for Grades 1 and 3

3. In 1979

    a. produce curriculum outlines for Grades 5 and 6
    b. complete data analyses and final reports

Although the AID/Stanford support under the new contract remained at approximately the same level as before, the MEP substantially increased its commitment for 1978. For the last half of 1977 the Ministry was bound by their previously established budget. However, for 1978 they agreed to the following additional support:

1. ten new staff positions

2. use of recording facilities up to 40 hours per month

3. broadcasting facilities for 2 hours per day (up from 1 hour)

4. supplies up to C$60,000 (new)

5. purchase 50 radios for expansion of project (new)

V. EXPANSION OF THE PROJECT TO RIO SAN JUAN

During 1977 the government of Nicaragua formed a commission representing several different ministries to determine what special programs were needed to assist the inhabitants in the department of Rio San Juan, a poor and isolated region near the Costa Rica border. A project staff member, Juan Jose Montenegro, was appointed to this commission by the Minister of Education. Mr. Montenegro spent over a week in Rio San Juan with the commission studying the educational sector--visiting schools, and talking to parents, teachers and community leaders. The commission's report included a description of the present situation in education, and presented plans for new programs.

In addition to helping prepare the final report, Mr. Montenegro prepared a special slide-tape show on his findings in Rio San Juan. This effort was enthusiastically received by the Minister of Public Education. Not only was a special presentation made to officials in the Ministry, but another showing was arranged for members of the Nicaraguan Congress.

One of the Commission's recommendations was that the Radio Mathematics Project should expand into Rio San Juan as quickly as possible. A special budget and implementation plans were drawn up. In the end, however, it was decided to delay implementation there until the 1978 school year. There were several reasons for the delay. First, by the time the project could have been implemented, it would have been nearly half way through the 1977 school year. The project staff members thought that the children might have difficulty following the radio instructions and that they would not have covered the prerequisite materials. Second, the necessary funds were not immediately available to purchase the radios, print the teacher's guides and to send one or more staff members to Rio San Juan to help with teacher training.

The project did, however, undertake a small study at that time to determine difficulties children might have in starting to use the radio lessons half way through the year. A rural school in Masaya, one that had no previous experience with the project, was chosen for the study. Mid-year lessons were played by tape recorder and the children were given very brief instructions about how to respond. At the end of the week's study, we concluded that the children had had remarkably little difficulty in adjusting to the new lessons. The school, however, proved not to be as typical as we had hoped, and doubts remained as to the advisability of commencing the lessons so late in the school year. (See Fourth Annual Report, Searle et al., 1977, pp. 60-61 for a more complete description of the study.)

In September, 1977, Mr. Montenegro visited Rio San Juan to lay plans for implementing the project there in 1978. As part of his study, he checked the reception of Radio Nacional in various parts of the department and found that the lessons could be received in most of the schools.

Mr. Montenegro also gathered statistical data about the schools. There are 40 schools with 77 teachers in Grades 1 through 3 with 3,320 students, 1,634 in first grade, 1,258 in second grade and 428 in third grade.

To implement the program in Grades 1 to 3, the following materials would be needed:

1. 43 radios
2. 186,000 worksheets for 150 first-grade lessons
3. 45 teacher's guides for first grade
4. 20 teacher's guides for second grade
5. 25 teacher's guides for third grade

With the $2,000 from Japan Prize award, the Ministry of Public Education authorized Stanford to purchase radios. In December, 1977, Stanford bought 43 radios at a unit cost of $46.50. Early in 1978 these radios were sent to Rio San Juan.

The Ministry assigned two staff members to supervise the implementation of the radio mathematics lessons as part of their overall duties in Rio San Juan. The two supervisors, after receiving training by the project, developed and carried out a brief teacher training program for the teachers in Rio San Juan during February, 1978. They continue to oversee the implementation of the project there.

At present only the radio lessons for Grades 2 and 3 are being used in Rio San Juan. Grade 1 lessons are not being used because a sufficient supply of paper was not available in time to prepare the necessary worksheets. Grade 4 lessons could not be introduced because the teacher's guides, along with the lessons, are being prepared during the 1978 school year, and it was not possible to arrange frequent delivery of materials.

VI. PLANS FOR WIDE-SCALE IMPLEMENTATION OF PROJECT IN NICARAGUA

The obligations of the IMSSS and the MEP have been to develop and evaluate the radio programs on a limited scale. The focus of the work has been on curriculum development, lesson preparation, evaluation and research. To carry out these tasks, wide-scale implementation was not necessary and, in fact, probably would have been counter-productive in terms of the project objectives because of the staff requirements for such an undertaking.

Although implementation remains on a small-scale, the project has expanded geographically beyond what was initially planned. The project intended to work only in the department of Masaya, but in 1976 it expanded to the departments of Granada and Carazo in order to better carry out the evaluation activities. In 1978 the project expanded to another department, Rio San Juan. Although these departments comprise 16.5% of the country's school population, the project is not yet working with all students at each grade level in these departments.

In 1977 the project collected and organized the necessary data to determine the reception costs for implementing the project for each grade in each of the 16 departments. The information included:

1. Radios. The number and cost to provide one radio for each first-grade section. The maximum number of radios needed are determined by the number of first-grade classes, since these are more numerous than classes at any other grade level and radios can by shared.

2. Teacher's guides. The number and cost to provide guides for each teacher for each grade level of children in his/her class. For example, a teacher having students in Grades 1 through 4 would need four separate guides, one for each grade level.

3. Support materials for first-grade children. Number and cost of books of student worksheets, one for each child.

4. Teacher training. Cost for minimal program of teacher training at each grade level.

5. Supervision. Cost and personnel needed for program of teacher support and supervision.

The estimated costs for implementing the program on a nation-wide basis in 1979 for Grades 1 through 4 are:

Radios	U.S.$207,486
Teacher's Guides	45,468
Workbooks, First Grade	221,707
Teacher Training	19,009
Supervision	63,185
TOTAL	$556,855

The costs for radios, teacher's guides, workbooks and, to some extent, teacher training, would be depreciated over several years. Nevertheless, U.S.$556,855 represents the sum initially needed to implement the program nation-wide, and finding the money presents the major stumbling block to wide-scale implementation.

If the implementation program is spread out over several years, or is initially delayed, the total cost would probably be higher due to inflation, increased student population and inefficiencies of multiple purchases in lower quantities.

Some costs are not included: transmission, distribution of materials, Ministry and project support personnel (supervisors have been included), and further curriculum modification and development.

The number of students per grade estimated for 1979 are:

1st grade	149,157
2nd grade	78,624
3rd grade	54,415
4th grade	40,193
TOTAL	332,389

Thus, if the total initial reception costs were to be absorbed during the first year only, the cost per student would be U.S.$1.72.

Once the program is implemented, the additional maintenance costs per year would be:

Repair 20% of radio at U.S.$11.43	U.S.$ 8,300
Replace 20% radios at $64.28 (5-year life)	46,684
Replace 25% teacher's guides (4-year life)	11,367
Replace 25% first-grade workbooks (4-year life)	55,427
Teacher training (15% turnover)	2,851
Supervision (annual cost)	60,329
TOTAL	184,958

Thus, the maintenance cost per year is estimated at $0.57 per student. The total cost for initial implementation on a nationwide basis and maintenance over a five-year period for Grades 1 through 4 would be U.S.$0.80 per student per year. A more detailed discussion of implementation costs is presented by Wells and Klees (1978), who give projections through 1998 and include depreciation and estimates for revising lessons.

The reception costs per student would decrease by about 6% if children in Grades 5 and 6 were included. No new radios would have to be purchased, although the repair rate would increase slightly; no new supervisors would be necessary; and no workbooks would be needed. However, teacher's guides would have to be produced and there would be some teacher training.

The MEP wishes to implement the program on a large-scale, and has been trying to locate the necessary funds. It had hoped to get some assistance from a proposed AID educational loan, but it now seems unlikely that this loan will be approved. Presently the MEP is negotiating a loan with the World Bank, and hopes to have the necessary funds from outside sources and internal support to maintain the project and implement the programs on a wide scale starting in 1979 or 1980.

VII. JAPAN PRIZE

The second-grade "Lesson 171" was awarded the esteemed Japan Prize for Radio in February, 1977. This typical lesson, one of the final lessons of the school year, was submitted to the 11th Japan Prize International Educational Program through the Ministry of Public Education.

One hundred sixty-six radio and television programs were submitted to the contest by 92 broadcasting organizations from all parts of the world. The awarding of the Japan Prize to the Radio Mathematics Project was given considerable publicity in the two principal Managua newspapers and on television Channel II. Furthermore, at the at the request of the Minister of Public Education, an exhibition was organized--consisting of the Japan Prize Trophy, photographs, and written materials--that was displayed at the Ministry and the at normal schools throughout the country. The Project Associate Director, Mrs. Vitalia Vrooman, lectured at each normal school when the exhibition arrived, and presented a specially prepared slide-tape show produced by the project staff.

The project has received many inquiries as a result of the award. (See Section XIII for further details). To respond to these requests the project prepared an information packet containing a tape of the prize-winning lesson and supporting materials.

Part of the first-prize award was a check for U.S.$2,000. The Minister directed that the money be used to purchase radios to extend use of the project lessons into the department of Rio San Juan. In December, 1977, 43 radio were purchased with these funds and were distributed to schools in Rio San Juan in early 1978 under the supervision of project personnel.

VIII. STAFF VISIT TO COSTA RICA

From December 13-15 several Nicaraguan staff members visited a radio project in Costa Rica, the Instituto Costarricense de Ensenanza Radiofonica (ICER). The staff members, Vitalia Vrooman, Juan Jose Montenegro, and Norma Guadamuz Cermeno, were particularly interested in three aspects of ICER--curriculum, administration and budget.

ICER broadcasts a primary school program directed to adults based on the formal curriculum of the Ministry of Public Education. Presently there are 1,200 students studying at four levels from Grades 1 through 6. The institute has a staff of 12, 4 of whom work on developing materials. Formal scripts are not written; using an outline only, the teachers who prepare the materials record lessons.

Members of the Costa Rica project were very interested in the mathematics project, and requested many materials. Plans were initiated to arrange a visit to Nicaragua by some of the Costa Rican institute members.

The Nicaraguan staff was impressed by how much the institute was able to do with such a limited staff and budget (about $35,000 per year). They all felt the visit was a worthwhile learning experience for themselves and the Costa Ricans.

IX. LISTENER SURVEY

In November 1977 we carried out an informal survey to get some idea of the number of people listening to our broadcasts who were not actually involved with the project. As a formal survey was considered too expensive, we decided to invite people to write to the project office. Those sending letters would be eligible for a drawing for a new transistor radio.

Between October 28 and November 4 we included in each broadcast a message telling them about the drawing and asking them to write. The message was placed in both the second- and third-grade lessons immediately after the theme music. We did not exclude the school classes used by the project, but asked that each class send only one letter.

The results were disappointing in terms of number of letters received, but very interesting for the diversity and quality of the letters. We received about 50 letters, but 35 were from a class that is involved with the project. The low response may or may not indicate a small number of listeners; it may only mean that the procedure for finding out who was listening was not good, at least in Nicaragua. Since we received letters from only one class involved with the project (out of 113), it may be that a correspondingly small percentage of other listeners wrote to us.

Several factors might have increased the number of responses. A more valuable prize (a color TV or new car) might have induced more people to write. Also the timing could have been better: the survey came soon after political disturbances; it was close to the end of the year; and it occurred during Communications Week when the postal rates were double.

Although the number of responses was disappointing, the geographical distribution of the listeners was interesting. We received letters from virtually every corner of the country, except for the Atlantic region and northeast, where the broadcasts cannot be heard clearly with the present facilities. The replies came from such disperse locations as the island of Ometepe in Lake Nicaragua (near Costa Rica), San Francisco del Norte in the northwest (near Honduras), and Puerto La Esperanza in the east (near the end of the Rama road). We also received a letter from a listener in Costa Rica (near the Nicaraguan border).

X. OTHER STUDIES

A. Observation Study

Thomas Tilson completed his doctoral dissertation based on a classroom observation study. The research focused on the activities and behaviors in first-grade classes using the radio lessons, and compared these activities with those in traditional classes. Among many other findings, he verified the high rate of student activity during the radio broadcasts, and isolated several behaviors that were significantly correlated with student achievement. A further description can be found in the forthcoming book (Suppes et al., in preparation).

The data collected for the observation study are being analyzed in considerable mathematical and statistical detail, as a part of a program to develop stochastic models of classroom behavior. This work is being done by two graduate students, John Sheehan and Naihua Duan, under the supervision of Professor Suppes.

B. Weekly Test Data

William J. Wagner, a doctoral student in the School of Education at Stanford, is completing a dissertation based upon the weekly test data. He has developed a performance model for addition exercises and applies mathematical learning theory to the model. One of the aims of his study is to use the weekly test data to predict student performance. Such work has a practical application in illuminating the relationship between the amount of practice students get and the amount of performance improvement that can be expected. Such an issue has great relevance for the design of curriculum as used by the project.

C. Analysis of Addition and Subtraction Data

Data from the addition and subtraction test (described in previous annual reports) is being used by Michael Cohen, a graduate student, who is working with Professor Suppes to elaborate models for the way students perform standard algorithms. This work can be expected to shed light on sources of student difficulty and hence impact on the design of instructional sequences.

D. Inteviews with Children

In July 1977 Marvin Saballos, a Nicaraguan staff psychologist, interviewed 19 radio mathematics third-grade students in an attempt to increase our understanding of the thinking processes students use while solving arithmetic exercises.

In previous analyses of incorrect responses to test items, we found patterns of errors that can be explained by hypothesizing the use of well-defined, but incorrect algorithms. One of the purposes of the interviews was to find out if the children's verbal description of

their thinking process confirms these hypotheses. A second purpose was to provide us with further hypotheses.

The errors observed held few surprises and the children's description of the processes confirmed many of our hypotheses. For example, we found as expected that children working subtraction exercises had great difficulty with borrowing but that frequently the difficulty lay in the decision to borrow and not in the borrowing process. Such findings have clear implications for instructional design.

We also examined the language used by the children in describing their thinking. We found, to our surprise, that students were quite fluent in their descriptions. As expected, the radio students adopted some of the phrasing used by the radio lessons but in general they did not seem better able to express themselves than students from traditional classes.

E. Collaboration with the World Bank

The Institute has two small contracts with the World Bank for work that is being done in collaboration with the project. The first contract is designed to produce findings on problems of dropout and repetition. Dean Jamison, a Bank educational economist who has worked with the project since its inception, has used project data on students, schools, and teachers to build a recursive regression model of the determinants of repetition. His work will be published in the forthcoming book (and elsewhere) and a reference is included in the project bibliography.

The second World Bank contract, which is being supervised by Dr. Stephen Heyneman of the Education Department of the Bank, will examine the impact of textbook use on student achievement in mathematics. Randomly selected classes at the first- and fourth-grade levels were given textbooks (enough for one per child) and the teachers provided with about the same level of training as is used for the radio lessons. Performance of students using texts will be compared with project control and radio classes.

We cannot stress enough the value of piggybacking these kinds of experiments. With a very small investment on the part of the Bank we are able to extend our work significantly and examine questions that are of great interest though not directly relevant to our central purpose. We feel that everyone gains by this broadening of our work.

XI. WORK PLANS FOR 1978 AND 1979

During 1978 the project is broadcasting lessons to children in grades 1 through 4. Children at all four grade levels in participating schools in the departments of Masaya, Granada and Carazo are using the lessons. In addition, children in Grades 2 and 3 are using the lessons in Rio San Juan.

The lessons for Grades 2 and 3 are the same as those broadcast during 1977. In first grade the lessons for the early part of the year are similar to those broadcast during 1976. For the last third of the school year, the lessons will be rewritten to eliminate the use of worksheets. One half of the classes will use each type of lesson, allowing a comparison of the effectiveness of teaching at the first-grade level with and without worksheets.

The fourth-grade lessons are being developed during 1978; both formative and summative evaluations are being carried out on the curriculum.

1978 is the last year planned for Stanford personnel to remain in Nicaragua. At the end of the school year the final data will be collected and the Stanford contribution in Nicaragua will be closed down. The last Stanford employee will return to California early in 1979 when all data collection has been completed.

XII. PROJECT ADMINISTRATION

During 1977 the project staff included two North Americans and approximately 28 full-time Nicaraguans. In addition, seven people worked part-time as actors and technicians involved with the recording of lessons. The office has six major departments--curriculum, radio production, research and evaluation, teacher training, materials production, and support. The Fourth Annual Report (Searle et al., 1977, pp. 75-76) describes the allocation of project personnel to departments, and provides further information on the tasks within each department.

The Stanford staff members have striven from the beginning of our work in Nicaragua to train Nicaraguan staff members to exercise positions of leadership in the project. At this time, almost all departments are headed by Nicaraguans and the Stanford staff members move increasingly to positions of technical advisors on matters of curriculum development and research design. Vitalia Rojas Vrooman has made substantial contributions to the development of curriculum master plans and lesson outlines. Norma Guadamuz Cermeno has full responsibility for all matters relating to the writing of scripts and production of broadcast tapes. Juan Jose Montenegro is in charge of all teacher training, and the production and dissemination of materials. Alicia Gordillo de Quintanilla directs the classroom observation and testing programs. She handles the preparation and administration of the tests, and the data analyses and summaries from the classroom observations.

XIII. DISSEMINATION AND UTILIZATION OF RESEARCH RESULTS

The project has received many inquiries from all parts of the world, particularly since the project won the Japan Prize in 1977. Representatives from the following countries have requested and been sent materials from January, 1977 through March, 1978.

Argentina	Italy
Brazil	Lesotho
Canada (2)	New Guinea
Colombia	Philippines
Dominican Republic	Sierre Leone
Egypt	South Africa
England (3)	Spain
Greece	Sweden
India	Western Samoa

In addition to the requests from abroad, there have been many inquiries from within the United States--universities, public school systems, and radio and television stations.

California (4)	New Mexico
Colorado	New York
District of Columbia	Ohio
Georgia	Pennsylvania
Hawaii	South Carolina
Massachusetts	Wisconsin
Michigan (2)	

A full list of the papers and publications prepared during the year follows:

Jamison, D. Radio education and student repetition in Nicaragua. In B. Searle, J. Friend, & P. Suppes, The Radio Mathematics Project, Nicaragua 1976. Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, in preparation.

Sachar, J., & Suppes, P. Estimating total-test scores from partial scores in a matrix sampling design. Unpublished manuscript, Stanford University, Institute for Mathematical Studies in the Social Sciences, 1977.

Searle, B., Friend, J., Suppes, P., & Tilson, T. Application of radio to teaching elementary mathematics in a developing country (4th annual report). Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, 1977.

Searle, B., & Suppes, P. The Nicaragua Radio Mathematics Project. In Proceedings, International Conference on Evaluation and Research in Educational Broadcasting, January 1977. [Also, in T. Bates & J. Robinson (Eds.), Evaluating educational television and radio. Milton Keynes, England: The Open University Press, 1977.]

Searle, B., & Suppes, P. Achievement levels of students learning primary-school mathematics by radio in Nicaragua. Studies in Science and Mathematics Education, in press.

Searle, B., Suppes, P., & Friend, J. The Nicaraguan radio mathematics project. In P. Spain, D. Jamison, & E. McAnany (Eds.), Radio for Education and Development: Case Studies (Vol 1). Washington, D.C.: The World Bank, 1977.

Wells, S., & Klees, S. Education decisions and cost analysis: The Radio Mathematics Project in Nicaragua. In B. Searle, J. Friend, & P. Suppes, The Radio Mathematics Project, Nicaragua 1976. Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, in prepartion.

Presented by Jamesine Friend:
Searle, B., & Suppes, P. Computer usage in the Nicaragua Radio Mathematics Project. In J. A. Jordan, Jr., & K. Malaivongs (Eds.), Proceedings of the International Conference on Computer Applications in Developing Countries, Bangkok: Asian Institute of Technology, August 1977.

Presented by Patrick Suppes:
Suppes, P., Zanotti, M., & Searle, B. Nicaragua Radio Mathematics Project: The role of probabilistic models in data analysis. Paper presented at the 41st session of the International Statistical Institute, New Delhi, India, December 1977.

Presented by Vitalia Vrooman:
Vrooman, V. [Teaching mathematics by radio.] Ensenanza de matematica usando radio. Paper presented at a conference sponsored by PRONTEL in Brazil, February 1978.

Presented by Dean Jamison:
Jamison, D. Radio education and student repetition in Nicaragua. Paper presented at the 22nd Annual Meeting of the Comparative and International Education Society, Mexico City, Mexico, March 1978.

Presented by Barbara Searle:
Searle, B., Matthews, P., Suppes, P., & Friend, J. Formal evaluation of the Nicaragua radio mathematics instructional program. Paper presented at the 22nd Annual Meeting of the Comparative and International Education Society, Mexico City, Mexico, March 1978.

In addition to the above papers and publications, project staff prepared a number of presentations for various interested organizations:

Barbara Searle presented a seminar on the project at the Center for Educational Technology in Israel, March, 1977.

The project staff, under the direction of Thomas Tilson, completed a slide-tape show of the project. In the spring 1977 the slide-tape show was edited by the Academy for Educational Development in Washington, D.C., and the sound-track was prepared in French, Spanish, and English. This slide-tape shown has been shown:

In Central African Empire--Barbara Searle presented a seminar on the project to educators in April 1977.

In Cameroon--Barbara Searle presented a seminar on the project to educators in April 1977.

In Sierra Leone--Barbara Searle presented a seminar on the project to educators in October 1977.

In Liberia--Barbara Searle presented a seminar on the project to educators in October 1977.

In Iran--Dexter Fletcher gave a talk on the project at the National Iranian Center for Educational Radio and Television in February 1978.

In Mexico City--Barbara Searle attended the 22nd Annual Meeting of the Comparative and International Education Society and presented the slide-tape show in March 1978.

Barbara Searle presented a workshop on the Nicaragua Radio Mathematics Project, complete with slide-tape show, to the the National Academy of Educational Broadcasters in Washington, D.C., November, 1977.

Barbara Searle participated in a discussion and described the project to a group of people in February 1978. The group included people from Stanford University, Dra. Rosa Luz Alegria (Undersecretary for Evaluation, Government of Mexico), and several collegues of hers.

XIV. INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN

There are five full-time professionals on the Stanford staff of the Radio Mathematics Project, two of whom work in Nicaragua. Two of these are women. The full-time staff members at Stanford are the project coordinator (female), a research assistant (Spanish surname), and a secretary (female). Part-time people include a statistician and four graduate students.

IMSSS has through its existence maintained a congenial atmosphere for both men and women of all types of backgrounds. That the Project Director in Nicaragua and the Project Coordinator at IMSSS are both women is not an unusual circumstance. Although the project has no plans to increase the size of the full-time staff, any replacements will be made within the policy guidelines for Stanford University that call for active recruiting of women and minority personnel.

XV. REFERENCES

Friend J. Closing the feedback loop. Paper presented at the international conference: The Use of Radio as an Instructional Tool in Primary Schools, Managua, Nicaragua, September 1976.

Searle, B., Friend, J., & Suppes, P. The Radio Mathematics Project: Nicaragua, 1974-1975. Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, 1977.

Searle, B., Friend, J., Suppes, P., & Tilson, T. Application of radio to teaching elementary mathematics in a developing country (4th annual report). Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, 1977.

Sirotnik, K. Introduction to matrix sampling for the practitioner. In W. J. Popham, (Ed.), Evaluation in Education. Berkeley, California: McCutchan Publishing Co., 1974.

Suppes, P., Searle, B., & Friend, J. (Eds.). The Radio Mathematics Project: Nicaragua, 1976. Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, in preparation.

Wells, S., & Klees, S. Education decisions and cost analysis: The Radio Mathematics Project in Nicaragua. In B. Searle, J. Friend, & P. Suppes, The Radio Mathematics Project: Nicaragua 1976. Stanford, Calif.: Stanford University, Institute for Mathematical Studies in the Social Sciences, in prepartion.

APPENDIX A: DATA TABLES

Table A

Performance of Experimental and Control Students on 1977 Second-Grade Posttest

Exercise (Type)[a]	Item Form	Percentage Correct: Experimental	Percentage Correct: Control	Description of Exercise
1(I)	I	41.0	49.1	Write the number that comes after 349
1(I)	II	77.9	70.8	Write the number that comes after 71
1(I)	III	52.9	63.2	Write the number that comes after 682
1(I)	IV	69.8	74.6	Write the number that comes after 39
1(I)	V	66.9	70.2	Write the number that comes after 306
2(I)	I	83.9	85.5	Count the beans and write the numeral on the line (25 beans)
2(I)	II	86.7	86.7	Count the beans and write the numeral on the line (32 beans)
2(I)	III	96.8	93.4	Count the beans and write the numeral on the line (8 beans)
2(I)	IV	90.6	88.2	Count the beans and write the numeral on the line (17 beans)
2(I)	V	82.5	76.0	Count the beans and write the numeral on the line (40 beans)
3(I)	I	6.2	8.2	Circle the largest number (1/4 1/2 1/3)
3(I)	II	69.6	60.2	Circle the largest number (923 479 150)
3(I)	III	83.9	77.4	Circle the largest number (59 73 75)
3(I)	IV	2.5	5.5	Circle the largest number (1/10 1/5 1/4)
3(I)	V	48.7	44.2	Circle the largest number (34 401 149)
4(G)	I	88.7	89.3	Circle 7359 (3759 9537 7359 7539)
4(G)	II	95.8	93.9	Circle 690 (69 690 960 96)

(Table A, Continued)

Exercise (Type)	Item Form	Percentage correct: Experimental	Percentage correct: Control	Description of Exercise
4(G)	III	87.3	92.6	Circle 706 (706 760 607 76)
4(G)	IV	95.0	97.3	Circle 74 (40 74 47 70)
4(G)	V	96.4	92.1	Circle 241 (142 421 251 241)
5(G)	I	92.5	81.3	Write 237
5(G)	II	55.4	33.3	Write 2989
5(G)	III	76.4	92.6	Write 608
5(G)	IV	83.5	96.4	Write 71
5(G)	V	88.6	81.9	Write 830
6(G)	I	66.0	57.1	Circle the 8th soldier
6(G)	II	97.6	93.9	Circle the 2nd soldier
6(G)	III	89.2	78.7	Circle the 4th soldier
6(G)	IV	46.0	39.6	Circle the 10th soldier
6(G)	V	77.1	79.5	Circle the 6th soldier
7(I)	I	82.0	59.1	842 + 41
7(I)	II	82.3	62.0	41 + 30
7(I)	III	82.6	68.9	3886 +5102
7(I)	IV	73.0	65.5	504 + 132
7(I)	V	76.6	42.3	26 + 3
8(G)	I	85.5	76.8	Circle the figure divided in half
8(G)	II	83.1	74.8	Circle the figure divided in fourths
8(G)	III	86.6	84.0	Circle the figure divided in fifths
8(G)	IV	65.5	51.4	Circle the figure divided in tenths
8(G)	V	47.6	33.1	Circle the figure divided in thirds
9(I)	I	87.0	82.7	9 + 6 =
9(I)	II	78.5	69.0	50 + 20 =

(Table A, Continued)

Exercise (Type)	Item Form	Percentage correct: Experimental	Percentage correct: Control	Description of Exercise
9(I)	III	43.9	37.7	400 + 65 =
9(I)	IV	67.3	69.1	73 + 6 =
9(I)	V	81.2	68.3	58 + 5 =
10(I)	I	57.8	57.3	Write the value of this group of money: 50c + 50c
10(I)	II	50.6	41.6	Write the value of this group of money: 5c + 50c
10(I)	III	49.0	48.1	Write the value of this group of money: 25c + 10c + 5c
10(I)	IV	46.5	46.4	Write the value of this group of money: 10c + 50c
10(I)	V	41.6	36.5	Write the value of this group of money: 25c + 10c + 25c
11(I)	I	70.2	57.3	723 - 621
11(I)	II	65.8	43.4	376 - 56
11(I)	III	69.7	36.8	76 - 5
11(I)	IV	73.6	64.6	66 - 64
11(I)	V	68.8	49.0	7533 -2010
12(G)	I	64.2	33.0	How much is 800 plus 25?
12(G)	II	78.3	73.7	How much is 40 plus 50?
12(G)	III	90.5	94.7	How much is 7 plus 5?
12(G)	IV	84.9	90.1	How much is 48 plus 4?
12(G)	V	88.0	89.0	How much is 33 plus 2?
13(I)	I	79.5	64.6	8 - 6 =
13(I)	II	63.9	48.7	60 - 40 =
13(I)	III	56.1	38.7	69 - 9 =
13(I)	IV	56.6	55.5	17 - 8 =
13(I)	V	72.1	50.0	13 - 5 =
14(G)	I	56.6	56.3	How much is 70 minus 60?
14(G)	II	76.5	60.6	How much is 16 minus 8?
14(G)	III	78.3	77.7	How much is 11 minus 4?

(Table A, Continued)

Exercise (Type)	Item Form	Percentage correct: Experimental	Percentage correct: Control	Description of Exercise
14(G)	IV	93.5	90.1	How much is 8 minus 4?
14(G)	V	77.1	56.7	How much is 85 minus 5?
15(I)	I	51.6	38.2	570 + 93
15(I)	II	71.5	61.1	64 + 28
15(I)	III	72.9	51.0	667 +204
15(I)	IV	64.2	53.6	147 +667
15(I)	V	74.7	56.7	39 + 68
16(G)	I	87.4	71.4	How much is 2 times 3?
16(G)	II	57.2	49.5	How much is 6 divided by 2?
16(G)	III	76.4	88.3	How much is 3 times 5?
16(G)	IV	92.1	87.4	How much is 4 times 2?
16(G)	V	57.8	48.0	How much is 8 divided by 4?
17(I)	I	32.9	22.7	546 - 127
17(I)	II	47.5	23.9	82 - 59
17(I)	III	31.6	12.3	865 - 497
17(I)	IV	23.9	22.7	4734 -1917
17(I)	V	43.5	13.5	67 - 8
18(G)	I	54.1	25.0	Write what time it is on that clock (4:00)
18(G)	II	9.0	3.0	Write what time it is on that clock (2:30)
18(G)	III	11.5	26.6	Write what time it is on that clock (8:15)
18(G)	IV	85.7	77.5	How many days are there in a week?

(Table A, Continued)

Exercise (Type)	Item Form	Percentage Correct: Experimental	Percentage Correct: Control	Description of Exercise
18(G)	V	87.4	88.2	Which is the longest? (month day year)
19(I)	I	64.6	58.2	2413 x 2
19(I)	II	86.7	74.3	4 x 2
19(I)	III	50.3	44.3	324 x 3
19(I)	IV	45.3	51.8	36 x 2
19(I)	V	76.6	63.5	32 x 3
20(G)	I	2.5	1.8	Write how many grams there are in a kilogram
20(G)	II	83.7	84.9	Circle the parallel lines
20(G)	III	44.6	73.4	Circle the angle
20(G)	IV	37.4	32.4	Which is longer? (decimeter centimeter meter)
20(G)	V	44.6	50.4	Write how many centimeters there are in a meter
21(I)	I	50.9	41.8	12 : 3
21(I)	II	67.1	59.3	6 : 2
21(I)	III	66.5	48.1	8 : 4
21(I)	IV	66.5	64.6	9 : 3
21(I)	V	71.4	70.2	8 : 2
22(I)	I	72.7	71.8	In that square there is money ($2 and $2). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
22(I)	II	77.2	77.0	In that square there is money ($10). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.

(Table A, Continued)

Exercise (Type)	Item Form	Percentage Correct Experimental	Control	Description of Exercise
22(I)	III	76.1	71.7	In that square there is money ($5). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
22(I)	IV	44.0	41.8	In that square there is money ($50). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
22(I)	V	66.2	61.5	In that square there is money ($20). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
23(I)	I	36.7	29.1	2/5 - 1/5
23(I)	II	39.9	34.5	2/10 + 5/10
23(I)	III	52.3	34.9	1/3 + 1/3
23(I)	IV	47.2	45.5	2/5 + 1/5
23(I)	V	41.6	20.2	5/10 - 2/10
24(G)	I	69.8	44.6	Roger arrived at school at 8:00 and Luis arrived 2 hours later. What time did Luis arrive? (6:00 8:00 10:00 12:00)
24(G)	II	38.6	37.4	Mr. Sanchez's oxen are able to plough 4 fields a day. How many fields are they able to plough in half a day? (4 1/2 2 8)
24(G)	III	86.6	72.3	Jose's mother made 12 biscuits. Jose ate 5. How many biscuits were left? (5 12 17 7)
24(G)	IV	83.5	84.7	Elena ate 4 mamones and then ate 3 more. Chico ate 5 mamones. How many did they eat in all? (12 9 8 7)

(Table A, Continued)

Exercise (Type)	Item Form	Percentage Correct: Experimental	Percentage Correct: Control	Description of Exercise
24(G)	V	64.5	68.5	Mrs Lopez sold 4 chickens for 3 cordobas each. How much money did she make? (C9 C12 C3 C7)
25(I)	I	77.6	75.5	Juan had 5 mangos and ate 2. How many does he have now? (3 10 7)
25(I)	II	77.9	77.9	Eva has 3 toys. Manolo has 3 others. How many toys do they have together? (6 9 3)
25(I)	III	69.7	75.5	Maria has 4 dahlias and 2 roses. How many flowers does she have in all? (2 6 8)
25(I)	IV	13.8	13.6	Maria has 6 carmels. Pedro has 5. Maria has more. How many more? (11 3 1)
25(I)	V	81.2	75.0	Nina bought 6 oranges. Her mother gave her 1 more. How many oranges does Nina have now? (6 7 5)

[a]Items labeled I are individual items, those labeled G are group items

Table B

Performance of Experienced and Nonexperienced Students
on 1977 Second-grade Posttest

Percentage Correct

Exercise (Type)[a]	Item Form	Nonexperienced Students	Experienced Students	Description of Exercise
1(I)	I	31.3	47.4	Write the number that comes after 349
1(I)	II	76.7	78.6	Write the number that comes after 71
1(I)	III	52.5	53.1	Write the number that comes after 682
1(I)	IV	63.9	73.5	Write the number that comes after 39
1(I)	V	59.7	71.1	Write the number that comes after 306
2(I)	I	81.3	85.6	Count the beans and write the numeral on the line (25 beans)
2(I)	II	81.7	89.8	Count the beans and write the numeral on the line (32 beans)
2(I)	III	96.6	96.9	Count the beans and write the numeral on the line (8 beans)
2(I)	IV	88.5	91.8	Count the beans and write the numeral on the line (17 beans)
2(I)	V	82.5	82.5	Count the beans and write the numeral on the line (40 beans)
3(I)	I	7.8	5.2	Circle the largest number (1/4 1/2 1/3)
3(I)	II	70.0	69.4	Circle the largest number (923 479 150)
3(I)	III	78.0	87.5	Circle the largest number (59 73 75)
3(I)	IV	3.3	2.0	Circle the largest number (1/10 1/5 1/4)
3(I)	V	40.4	53.6	Circle the largest number (34 401 149)
4(G)	I	91.8	86.7	Circle 7359 (3759 9537 7359 7539)
4(G)	II	96.8	94.4	Circle 690 (69 690 960 96)
4(G)	III	83.3	90.1	Circle 706 (706 760 607 76)

(Table B, Continued)

Exercise (Type)	Item Form	Percentage Correct: Nonexperienced Students	Percentage Correct: Experienced Students	Description of Exercise
4(G)	IV	84.2	96.7	Circle 74 (40 74 47 70)
4(G)	V	95.1	97.1	Circle 241 (142 421 251 241)
5(G)	I	88.5	94.9	Write 237
5(G)	II	58.5	51.4	Write 2989
5(G)	III	71.2	80.2	Write 608
5(G)	IV	89.5	82.5	Write 71
5(G)	V	91.8	86.7	Write 830
6(G)	I	60.7	69.4	Circle the 8th soldier
6(G)	II	95.7	100.0	Circle the 2nd soldier
6(G)	III	89.4	89.0	Circle the 4th soldier
6(G)	IV	26.3	49.2	Circle the 10th soldier
6(G)	V	83.6	73.3	Circle the 6th soldier
7(I)	I	79.7	83.5	842 + 41
7(I)	II	83.3	81.6	41 + 30
7(I)	III	81.4	83.3	3886 +5102
7(I)	IV	72.1	73.5	504 + 132
7(I)	V	77.2	76.3	26 + 3
8(G)	I	82.0	87.8	Circle the figure divided in half
8(G)	II	84.0	81.9	Circle the figure divided in fourths
8(G)	III	83.3	89.0	Circle the figure divided in fifths
8(G)	IV	47.4	68.3	Circle the figure divided in tenths
8(G)	V	55.7	42.9	Circle the figure divided in thirds
9(I)	I	85.9	87.6	9 + 6 =
9(I)	II	75.0	80.6	50 + 20 =
9(I)	III	39.0	46.9	400 + 65 =
9(I)	IV	67.2	67.4	73 + 6 =
9(I)	V	82.5	80.4	58 + 5 =

(Table B, Continued)

Exercise (Type)	Item Form	Percentage Correct: Nonexperienced Students	Percentage Correct: Experienced Students	Description of Exercise
10(I)	I	64.1	53.6	Write the value of this group of money: 50c + 50c
10(I)	II	35.0	60.2	Write the value of this group of money: 5c + 50c
10(I)	III	44.1	52.1	Write the value of this group of money: 25c + 10c + 5c
10(I)	IV	45.9	46.9	Write the value of this group of money: 10c + 50c
10(I)	V	40.4	42.3	Write the value of this group of money: 25c + 10c + 25c
11(I)	I	73.4	68.0	723 - 621
11(I)	II	61.7	68.4	376 - 56
11(I)	III	67.8	70.8	76 - 5
11(I)	IV	65.6	78.6	66 - 64
11(I)	V	61.4	73.2	7533 -2010
12(G)	I	52.5	71.4	How much is 800 plus 25?
12(G)	II	74.5	83.3	How much is 40 plus 50?
12(G)	III	90.9	90.1	How much is 7 plus 5?
12(G)	IV	89.5	84.2	How much is 48 plus 4?
12(G)	V	88.5	87.6	How much is 33 plus 2?
13(I)	I	79.7	79.4	8 - 6 =
13(I)	II	71.7	59.2	60 - 40 =
13(I)	III	55.9	56.3	69 - 9 =
13(I)	IV	50.8	60.2	17 - 8 =
13(I)	V	61.4	78.4	13 - 5 =
14(G)	I	39.3	67.4	How much is 70 minus 60?
14(G)	II	73.4	80.6	How much is 16 minus 8?
14(G)	III	69.7	84.6	How much is 11 minus 4?
14(G)	IV	89.5	94.2	How much is 8 minus 4?
14(G)	V	75.4	78.1	How much is 85 minus 5?

(Table B, Continued)

Exercise (Type)	Item Form	Percentage Correct: Nonexperienced Students	Percentage Correct: Experienced Students	Description of Exercise
15(I)	I	50.0	52.6	570 + 93
15(I)	II	68.3	73.5	64 + 28
15(I)	III	62.7	79.2	667 +204
15(I)	IV	60.7	66.3	147 +667
15(I)	V	80.7	71.1	39 + 68
16(G)	I	82.0	90.8	How much is 2 times 3?
16(G)	II	62.8	50.0	How much is 6 divided by 2?
16(G)	III	66.7	83.5	How much is 3 times 5?
16(G)	IV	94.7	91.7	How much is 4 times 2?
16(G)	V	59.0	57.1	How much is 8 divided by 4?
17(I)	I	31.3	34.0	546 - 127
17(I)	II	50.0	45.9	82 - 59
17(I)	III	28.8	33.3	865 - 497
17(I)	IV	24.6	23.5	4734 -1917
17(I)	V	33.3	49.5	67 - 8
18(G)	I	34.4	66.3	Write what time it is on that clock (4:00)
18(G)	II	8.5	9.7	Write what time it is on that clock (2:30)
18(G)	III	15.2	8.8	Write what time it is on that clock (8:15)
18(G)	IV	47.4	91.7	How many days are there in a week?
18(G)	V	85.3	88.6	Which is the longest? (month day year)

(Table B, Continued)

Exercise (Type)	Item Form	Percentage Correct: Nonexperienced Students	Percentage Correct: Experienced Students	Description of Exercise
19(I)	I	65.6	63.9	2413 x 2
19(I)	II	83.3	88.8	4 x 2
19(I)	III	47.5	52.1	324 x 3
19(I)	IV	41.0	48.0	36 x 2
19(I)	V	63.2	84.5	32 x 3
20(G)	I	1.6	3.1	Write how many grams there are in a kilogram
20(G)	II	79.8	88.9	Circle the parallel lines
20(G)	III	40.9	47.3	Circle the angle
20(G)	IV	5.3	42.5	Which is longer? (decimeter centimeter meter)
20(G)	V	39.3	47.6	Write how many centimeters there are in a meter
21(I)	I	43.8	55.7	12 : 3
21(I)	II	71.7	64.3	6 : 2
21(I)	III	67.8	65.6	8 : 4
21(I)	IV	55.7	70.4	9 : 3
21(I)	V	61.4	77.3	8 : 2
22(I)	I	81.3	67.0	In that square there is money ($2 and $2). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
22(I)	II	81.7	74.5	In that square there is money ($10). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.

(Table B, Continued)

Exercise (Type)	Item Form	Percentage Correct: Nonexperienced Students	Percentage Correct: Experienced Students	Description of Exercise
22(I)	III	74.6	77.1	In that square there is money ($5). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
22(I)	IV	42.6	44.9	In that square there is money ($50). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
22(I)	V	54.4	73.2	In that square there is money ($20). Mr. Jose is going to buy a melon. The melon which he wants costs 3 cordobas. Write how many cordobas will be returned to him.
23(I)	I	28.1	42.3	2/5 - 1/5
23(I)	II	31.7	44.9	2/10 + 5/10
23(I)	III	40.7	59.4	1/3 + 1/3
23(I)	IV	32.8	56.1	2/5 + 1/5
23(I)	V	21.1	53.6	5/10 - 2/10
24(G)	I	73.8	67.4	Roger arrived at school at 8:00 and Luis arrived 2 hours later. What time did Luis arrive? (6:00 8:00 10:00 12:00)
24(G)	II	35.1	43.1	Mr. Sanchez's oxen are able to plough 4 fields a day. How many fields are they able to plough in half a day? (4 1/2 2 8)
24(G)	III	87.9	85.7	Jose's mother made 12 biscuits. Jose ate 5. How many biscuits were left? (5 12 17 7)
24(G)	IV	79.0	84.2	Elena ate 4 mamones and then ate 3 more. Chico ate 5 mamones. How many did they eat in all? (12 9 8 7)

(Table B, Continued)

Exercise (Type)	Item Form	Percentage Correct: Nonexperienced Students	Percentage Correct: Experienced Students	Description of Exercise
24(G)	V	75.4	58.1	Mrs Lopez sold 4 chickens for 3 cordobas each. How much money did she make? (C9 C12 C3 C7)
25(I)	I	79.7	76.3	Juan had 5 mangos and ate 2. How many does he have now? (3 10 7)
25(I)	II	73.3	80.6	Eva has 3 toys. Manolo has 3 others. How many toys do they have together? (6 9 3)
25(I)	III	64.4	72.9	Maria has 4 dahlias and 2 roses. How many flowers does she have in all? (2 6 8)
25(I)	IV	9.8	16.3	Maria has 6 carmels. Pedro has 5. Maria has more. How many more? (11 3 1)
25(I)	V	77.2	83.5	Nina bought 6 oranges. Her mother gave her 1 more. How many oranges does Nina have now? (6 7 5)

[a]Items labeled I are individual items, those labeled G are group items.

Table C

Performance of Experimental and Control Students on Third-Grade Posttest

Exercise (Type)[a]	Item Form	Percentage Correct: Experimental	Percentage Correct: Control	Description of Exercise
1(I)	I	91.5	84.4	Write the number that comes after 39
1(I)	II	86.9	78.8	Write the number that comes after 306
1(I)	III	70.5	62.4	Write the number that comes after 349
1(I)	IV	72.3	50.9	Write the number that comes after 4531
2(I)	I	85.9	82.8	9 + 6 + 7 =
2(I)	II	70.1	73.5	504 +132
2(I)	III	80.0	59.8	60 - 40 =
2(I)	IV	60.4	42.6	400 + 65 =
3(I)	I	41.5	45.9	Circle the largest number (2341 1694 989)
3(I)	II	2.8	8.0	Circle the largest number (1/3 2/3 2/6)
3(I)	III	6.7	3.4	Circle the largest number (1/2 1/5 1/3)
3(I)	IV	60.4	49.1	Circle the largest number (34 401 149)
4(I)	I	80.2	63.9	364 +280
4(I)	II	87.9	78.8	64 +28
4(I)	III	94.3	85.5	23 41 10 +24
4(I)	IV	78.2	33.3	3526 + 3
5(G)	I	90.8	70.0	Write 2,989
5(G)	II	85.3	86.2	Write 830
5(G)	III	21.4	31.7	Write 5 1/2
5(G)	IV	32.3	34.2	Write 32,000

(Table C, Continued)

Exercise (Type)	Item Form	Percentage correct Experimental	Control	Description of Exercise
6(I)	I	62.0	47.5	570 + 93
6(I)	II	73.8	70.8	392 67 +411
6(I)	III	69.5	58.1	539 128 +217
6(I)	IV	73.3	34.3	695 + 8
7(G)	I	64.6	53.3	45 + 22
7(G)	II	62.4	50.5	800 + 25
7(G)	III	86.6	80.8	48 + 4
7(G)	IV	67.7	55.9	18 + 70
8(I)	I	70.8	26.2	3.26 +4.1
8(I)	II	57.9	25.7	6.93 +1.51
8(I)	III	81.9	74.4	212 x 4
8(I)	IV	87.1	33.3	2.5 +4.3
9(G)	I	0.0	0.0	Write the words for 743
9(G)	II	85.3	90.8	Circle the figure divided in 5ths
9(G)	III	0.0	0.0	Write the words for 216
9(G)	IV	37.6	44.1	Circle the figure divided in 3rds
10(G)	I	0.0	64.2	Which is longest? (yard meter inch)
10(G)	II	85.3	6.4	How many days are in a year?
10(G)	III	0.0	27.5	What is the length of this pencil?
10(G)	IV	37.6	41.4	How many cm. are in a meter?

(Table C, Continued)

Exercise (Type)	Item Form	Percentage correct Experimental	Control	Description of Exercise
11(I)	I	19.8	2.5	6 x 0 x 2
11(I)	II	22.4	15.0	3 x 4 x 2
11(I)	III	82.9	83.8	2413 x 2
11(I)	IV	54.5	31.5	5 x 1 x 3
12(G)	I	6.2	8.3	This figure is 2 cm wide and 4 cm long. What is the perimeter?
12(G)	II	8.3	1.8	This figure is 2 cm wide and 4 cm long. What is the area?
12(G)	III	4.5	2.5	A garden is 2 meters wide and 4 meters long. What is the perimeter?
12(G)	IV	3.0	5.4	A window is 2 feet high and 4 feet across. What is the area?
13(I)	I	82.1	59.8	68 - 5
13(I)	II	65.4	41.6	13 - 9
13(I)	III	51.4	25.6	546 -127
13(I)	IV	72.3	41.7	82 -59
14(G)	I	89.2	84.2	Circle the 9th soldier
14(G)	II	78.9	78.9	Circle the 8th soldier
14(G)	III	86.6	87.5	Circle the smallest number (41 38 36)
14(G)	IV	60.9	54.1	Circle the smallest number (599 735 757)
15(I)	I	44.3	39.3	4375 x 4
15(I)	II	65.4	58.4	528 x 6

(Table C, Continued)

Exercise (Type)	Item Form	Percentage correct: Experimental	Percentage correct: Control	Description of Exercise
15(I)	III	36.2	18.8	744 x 8
15(I)	IV	88.1	71.3	320 x 3
16(G)	I	86.2	68.3	How much is 500 - 100?
16(G)	II	33.9	33.0	How much is 600 - 7?
16(G)	III	85.7	80.0	How much is 11 - 4?
16(G)	IV	78.2	75.7	How much is 7 x 5?
17(I)	I	76.4	60.7	7533 -2010
17(I)	II	4.7	4.4	3259 x 50
17(I)	III	81.9	72.7	723 -621
17(I)	IV	5.0	6.5	431 x300
18(G)	I	36.9	37.5	Write what time it is on that clock (1:30)
18(G)	II	68.8	77.1	Write how many months follow May
18(G)	III	82.1	83.3	Write how many months are in a year
18(G)	IV	30.8	28.8	Write what time it is on that clock (4:00)
19(I)	I	62.3	20.5	5.75 -2.34
19(I)	II	37.4	16.8	6.28 -2.71
19(I)	III	60.0	18.0	8.43 -2.2
19(I)	IV	50.5	20.4	425 -279
20(G)	I	27.7	10.0	How much is 4 x 2 x 3?
20(G)	II	40.4	47.7	How much is 90 : 9?
20(G)	III	83.0	80.0	How much is 8 : 4?
20(G)	IV	53.4	51.4	How much is 8 x 100?

(Table C, Continued)

Exercise (Type)	Item Form	Percentage Correct Experimental	Control	Description of Exercise
21(I)	I	52.8	4.9	602 - 98
21(I)	II	69.2	33.6	0.85 -0.7
21(I)	III	75.2	62.4	12 : 3
21(I)	IV	84.2	66.7	8 : 4
22(G)	I	1.5	20.0	How many liters are in a kiloliter?
22(G)	II	12.8	9.2	How much is 2/3 of 9?
22(G)	III	20.5	27.5	How much is 1/4 of 12?
22(G)	IV	55.6	52.3	How much is 45 : 5?
23(I)	I	0.0	3.3	Circle the largest number (4.05 4.01 4.1)
23(I)	II	56.1	30.1	Circle the largest number (4 3/4, 7 1/2, 7)
23(I)	III	43.8	50.4	Circle the largest number (11, 2/10, 2)
23(I)	IV	86.1	83.3	Circle the largest number (2.36 2.09 2.29)
24(G)	I	72.3	34.2	Write 3 and 2/3
24(G)	II	1.8	0.0	Ride the bicycle 5 and 3 hundredths kilometers. Write. with numerals, the decimal 5.03
24(G)	III	68.8	5.0	Walk 2 and 7 tenths kilometers, Write, with numerals, the decimal 2.7
24(G)	IV	20.3	14.4	The hallway to the class measures 4 and 18 hundredths meters. Write, with numerals, the decimal 4.18
25(I)	I	17.9	30.3	95 : 5
25(I)	II	44.9	61.1	369 : 3
25(I)	III	30.5	29.9	78 : 5
25(I)	IV	12.9	22.2	560 : 7
26(G)	I	27.7	19.2	Circle the fraction that is equal to 1/2 (3/4 2/3 2/4)

(Table C, Continued)

Exercise (Type)	Item Form	Percentage Correct Experimental	Control	Description of Exercise
26(G)	II	1.8	10.1	Write this fraction in decimal form (1/10)
26(G)	III	5.4	15.0	Circle the fraction that is equal to 2/4 (3/4 2/3 1/2)
26(G)	IV	0.0	3.6	Write this fraction in decimal form (26/100)
27(I)	I	2.8	0.8	3/7 + 1/7 + 3 =
27(I)	II	65.4	50.4	5/10 - 2/10 =
27(I)	III	68.6	39.3	4/5 - 3/5 =
27(I)	IV	37.6	46.3	804 : 4
28(G)	I	30.8	16.7	Maria bought a box of biscuits for C$6.50. She paid for it with a C$10.00 bill. How much change will she get back?
28(G)	II	48.6	43.1	Sr. Sanchez has 7 bags with apples. Each bag has 6 apples. How many apples are there in all?
28(G)	III	46.4	48.3	Sr. Sanchez bought 7 books. Each book cost C$6. How much did they cost in all?
28(G)	IV	60.9	49.6	Circle the one that weighs the most. (pound, ounce, gram)
29(I)	I	83.0	49.2	2/5 + 1/5 =
29(I)	II	82.2	62.0	1/4 + 3/4 =
29(I)	III	80.0	55.6	1/3 + 1/3 =
29(I)	IV	83.2	49.1	2/6 + 2/6 =
30(G)	I	64.6	40.8	Sra. Lopez has 35 jocotes. She puts them in containers to sell. 7 jocotes will fit in each container. How many containers will she need?
30(G)	II	64.2	53.2	Sra. Lopez has 35 jocotes. She wants to divide them into groups so each of her 7 children will get the same number of jocotes. How many jocotes will she give to each child?

(Table C, Continued)

Exercise (Type)	Item Form	Percentage Correct Experimental	Control	Description of Exercise
30(G)	III	50.0	49.2	Sra. Lopez wants to make 35 dresses. She wants to make 7 dresses per day. How many days will it take to make all the dresses?
30(G)	IV	40.6	40.5	Sra. Lopez made 35 dresses. She worked 7 days making them. How many dresses did she make each day?
31(G)	I	81.5	79.2	When leaving the house this morning, I carried 13 bottle caps. On the road to school I met Juan, and gave him 7 bottle caps. How many caps do I have left?
31(G)	II	75.2	73.4	Juan is 13 years old. Carla is younger than Juan. She is 7 years old. Carla is how many years younger than Juan?
31(G)	III	81.3	74.2	When leaving the house this morning, I carried 13 bottle caps. On the road to school I was only carrying 7 bottle caps. How many did I lose?
31(G)	IV	72.2	82.0	Juan is 7 years old. Carla is older than Juan. She is 13 years old. How much older is Carla?
32(I)	I	68.9	73.0	I have 47 pictures in my photo album. Today in class I got 21 more. How many pictures are there in all?
32(I)	II	65.4	59.3	Juan bought 68 chicks. During the night the fox ate 12. How many chicks are left?
32(I)	III	13.3	16.2	On the road to school there is a row of 24 trees. This morning there were 6 birds in each tree. How many birds were there in all?

(Table C, Continued)

Exercise (Type)	Item Form	Percentage Correct: Experimental	Percentage Correct: Control	Description of Exercise
32(I)	IV	37.6	28.7	The teacher has 48 pencils to give to the best 4 students at the end of the year. How many pencils will she give to each student if they each receive the same number of pencils?

[a]Items labeled I are individual items, those labeled G are group items

Table D

Performance of Observed and Experienced Students on 1977 Third-grade Posttest

Exercise (Type)[a]	Item Form	Percentage Correct: Observed	Percentage Correct: Experienced	Description of Exercise
1(I)	I	94.7	84.1	Write the number that comes after 39
1(I)	II	90.3	83.7	Write the number that comes after 306
1(I)	III	73.4	55.6	Write the number that comes after 349
1(I)	IV	76.7	64.3	Write the number that comes after 4531
2(I)	I	89.5	95.5	9 + 6 + 7 =
2(I)	II	80.7	65.1	504 +132
2(I)	III	89.1	91.1	60 - 40 =
2(I)	IV	65.0	66.7	400 + 65 =
3(I)	I	58.9	43.2	Circle the largest number (2341 1694 989)
3(I)	II	0.0	0.0	Circle the largest number (1/3 2/3 2/6)
3(I)	III	12.5	4.4	Circle the largest number (1/2 1/5 1/3)
3(I)	IV	61.7	66.7	Circle the largest number (34 401 149)
4(I)	I	91.2	81.8	364 +280
4(I)	II	91.9	90.7	64 +28
4(I)	III	92.2	93.3	23 41 10 +24
4(I)	IV	91.7	83.3	3526 + 3
5(G)	I	90.6	87.0	Write 2,989
5(G)	II	95.2	94.0	Write 830
5(G)	III	30.4	29.0	Write 5 1/2
5(G)	IV	41.4	33.0	Write 32,000

(Table D, Continued)

Exercise (Type)	Item Form	Percentage correct: Observed	Percentage correct: Experienced	Description of Exercise
6(I)	I	73.7	79.6	570 + 93
6(I)	II	90.3	86.1	392 67 +411
6(I)	III	70.3	80.0	539 128 +217
6(I)	IV	88.3	71.4	695 + 8
7(G)	I	89.1	57.4	45 + 22
7(G)	II	73.1	74.0	800 + 25
7(G)	III	89.9	87.1	48 + 4
7(G)	IV	88.0	89.7	18 + 70
8(I)	I	87.7	84.1	3.26 +4.1
8(I)	II	80.7	72.1	6.93 +1.51
8(I)	III	92.2	91.1	212 x 4
8(I)	IV	95.0	85.7	2.5 +4.3
9(G)	I	0.0	0.0	Write the words for 743
9(G)	II	88.5	94.0	Circle the figure divided in 5ths
9(G)	III	0.0	0.0	Write the words for 216
9(G)	IV	81.0	79.5	Circle the figure divided in 3rds
10(G)	I	60.9	68.5	Which is longest? (yard meter inch)
10(G)	II	0.0	0.0	How many days are in a year?
10(G)	III	24.6	29.0	What is the length of this pencil?
10(G)	IV	74.1	89.7	How many cm. are in a meter?

(Table D, Continued)

Exercise (Type)	Item Form	Percentage correct Observed	Experienced	Description of Exercise
11(I)	I	35.1	13.6	6 x 0 x 2
11(I)	II	33.9	11.6	3 x 4 x 2
11(I)	III	87.5	88.9	2413 x 2
11(I)	IV	66.7	23.8	5 x 1 x 3
12(G)	I	1.6	5.6	This figure is 2 cm wide and 4 cm long. What is the perimeter?
12(G)	II	1.9	4.0	This figure is 2 cm wide and 4 cm long. What is the area?
12(G)	III	0.0	0.0	A garden is 2 meters wide and 4 meters long. What is the perimeter?
12(G)	IV	27.6	23.1	A window is 2 feet high and 4 feet across. What is the area?
13(I)	I	89.5	86.4	68 - 5
13(I)	II	85.5	88.4	13 - 9
13(I)	III	78.1	73.3	546 -127
13(I)	IV	85.0	71.4	82 -59
14(G)	I	93.8	93.3	Circle the 9th soldier
14(G)	II	86.5	92.0	Circle the 8th soldier
14(G)	III	81.2	93.5	Circle the smallest number (41 38 36)
14(G)	IV	60.3	66.7	Circle the smallest number (599 735 757)
15(I)	I	59.7	50.0	4375 x 4
15(I)	II	80.7	86.1	528 x 6

(Table D, Continued)

Exercise (Type)	Item Form	Percentage correct Observed	Experienced	Description of Exercise
15(I)	III	45.3	37.8	744 x 8
15(I)	IV	98.3	83.3	320 x 3
16(G)	I	87.5	75.9	How much is 500 - 100?
16(G)	II	44.2	49.5	How much is 600 - 7?
16(G)	III	89.9	90.3	How much is 11 - 4?
16(G)	IV	96.6	84.6	How much is 7 x 5?
17(I)	I	80.7	77.3	7533 -2010
17(I)	II	9.7	0.0	3259 x 50
17(I)	III	90.6	88.9	723 -621
17(I)	IV	8.3	0.0	431 x300
18(G)	I	43.8	7.4	Write what time it is on that clock (1:30)
18(G)	II	78.9	80.0	Write how many months follow May
18(G)	III	92.8	87.1	Write how many months are in a year
18(G)	IV	67.2	30.8	Write what time it is on that clock (4:00)
19(I)	I	71.9	75.0	5.75 -2.34
19(I)	II	61.3	53.5	6.28 -2.71
19(I)	III	81.3	71.1	8.43 -2.2
19(I)	IV	63.3	47.6	425 -279
20(G)	I	40.6	1.9	How much is 4 x 2 x 3?
20(G)	II	63.5	68.0	How much is 90 : 9?
20(G)	III	89.9	96.8	How much is 8 : 4?
20(G)	IV	86.2	76.9	How much is 8 x 100?

(Table D, Continued)

Exercise (Type)	Item Form	Percentage Correct Observed	Percentage Correct Experienced	Description of Exercise
21(I)	I	54.4	47.7	602 - 98
21(I)	II	79.0	79.1	0.85 -0.7
21(I)	III	84.4	82.2	12 : 3
21(I)	IV	96.7	83.3	8 : 4
22(G)	I	12.5	0.0	How many liters are in a kiloliter?
22(G)	II	5.8	18.0	How much is 2/3 of 9?
22(G)	III	42.0	9.7	How much is 1/4 of 12?
22(G)	IV	87.9	66.7	How much is 45 : 5?
23(I)	I	7.0	0.0	Circle the largest number (4.05 4.01 4.1)
23(I)	II	75.8	62.8	Circle the largest number (4 3/4, 7 1/2, 7)
23(I)	III	42.2	48.9	Circle the largest number (11, 2/10, 2)
23(I)	IV	86.7	78.6	Circle the largest number (2.36 2.09 2.29)
24(G)	I	81.3	57.4	Write 3 and 2/3
24(G)	II	0.0	40.0	Ride the bicycle 5 and 3 hundredths kilometers. Write, with numerals, the decimal 5.03
24(G)	III	60.9	83.9	Walk 2 and 7 tenths kilometers, Write, with numerals, the decimal 2.7
24(G)	IV	17.2	51.3	The hallway to the class measures 4 and 18 hundredths meters. Write, with numerals, the decimal 4.18
25(I)	I	31.6	29.6	95 : 5
25(I)	II	59.7	76.7	369 : 3
25(I)	III	26.6	24.4	78 : 5
25(I)	IV	26.7	9.5	560 : 7
26(G)	I	10.9	13.0	Circle the fraction that is equal to 1/2 (3/4 2/3 2/4)

(Table D, Continued)

Exercise (Type)	Item Form	Percentage Correct: Observed	Percentage Correct: Experienced	Description of Exercise
26(G)	II	11.5	8.0	Write this fraction in decimal form (1/10)
26(G)	III	5.8	22.6	Circle the fraction that is equal to 2/4 (3/4 2/3 1/2)
26(G)	IV	0.0	0.0	Write this fraction in decimal form (26/100)
27(I)	I	0.0	0.0	3/7 + 1/7 + 3 =
27(I)	II	72.6	79.1	5/10 - 2/10 =
27(I)	III	78.1	75.6	4/5 - 3/5 =
27(I)	IV	36.7	38.1	804 : 4
28(G)	I	10.9	20.4	Maria bought a box of biscuits for C$6.50. She paid for it with a C$10.00 bill. How much change will she get back?
28(G)	II	40.4	58.0	Sr. Sanchez has 7 bags with apples. Each bag has 6 apples. How many apples are there in all?
28(G)	III	62.3	22.6	Sr. Sanchez bought 7 books. Each book cost C$6. How much did they cost in all?
28(G)	IV	72.4	71.8	Circle the one that weighs the most. (pound, ounce, gram)
29(I)	I	91.2	81.8	2/5 + 1/5 =
29(I)	II	93.6	90.1	1/4 + 3/4 =
29(I)	III	92.2	88.9	1/3 + 1/3 =
29(I)	IV	92.7	81.0	2/6 + 2/6 =
30(G)	I	64.1	16.7	Sra. Lopez has 35 jocotes. She puts them in containers to sell. 7 jocotes will fit in each container. How many containers will she need?
30(G)	II	78.9	76.0	Sra. Lopez has 35 jocotes. She wants to divide them into groups so each of her 7 children will get the same number of jocotes. How many jocotes will she give to each child?

(Table D, Continued)

Exercise (Type)	Item Form	Percentage Correct Observed	Percentage Correct Experienced	Description of Exercise
30(G)	III	53.6	71.0	Sra. Lopez wants to make 35 dresses. She wants to make 7 dresses per day. How many days will it take to make all the dresses?
30(G)	IV	77.6	25.6	Sra. Lopez made 35 dresses. She worked 7 days making them. How many dresses did she make each day?
31(G)	I	85.9	94.4	When leaving the house this morning, I carried 13 bottle caps. On the road to school I met Juan, and gave him 7 bottle caps. How many caps do I have left?
31(G)	II	82.7	80.0	Juan is 13 years old. Carla is younger than Juan. She is 7 years old. Carla is how many years younger than Juan?
31(G)	III	87.0	93.6	When leaving the house this morning, I carried 13 bottle caps. On the road to school I was only carrying 7 bottle caps. How many did I lose?
31(G)	IV	91.4	84.6	Juan is 7 years old. Carla is 13 years old. How many years older is Carla?
32(I)	I	86.0	79.6	I have 47 pictures in my photo album. Today in class I got 21 more. How many pictures are there in all?
32(I)	II	82.3	72.1	Juan bought 68 chicks. During the night the fox ate 12. How many chicks are left?
32(I)	III	20.3	15.6	On the road to school there is a row of 24 trees. This morning there were 6 birds in each tree. How many birds were there in all?

(Table D, Continued)

Exercise (Type)	Item Form	Percentage Correct: Observed	Percentage Correct: Experienced	Description of Exercise
32(I)	IV	48.3	28.6	The teacher has 48 pencils to give to the best 4 students at the end of the year. How many pencils will she give to each student if they each receive the same number of pencils?

[a]Items labeled I are individual items, those labeled G are group items

Table E

Comparison of Third-grade Pretest and Posttest Scores on Identical Items for Experimental and Control Students

Item (Exercise-Form)	Topic	Percentage Correct: Control Posttest	Experimental Posttest	Pretest
1-I	Numeration	84.4	91.5	81.6
1-II	Numeration	78.8	86.9	78.4
1-III	Numeration	62.4	70.5	51.4
2-II	Addition	73.5	70.1	66.0
2-III	Subtraction	59.8	80.0	45.5
2-IV	Addition	42.6	60.4	39.7
3-I	Numeration	45.9	41.5	33.0
4-II	Addition	78.8	87.9	62.5
4-III	Addition	85.5	94.3	77.7
5-I	Numeration	70.0	90.8	56.8
5-II	Numeration	86.2	85.3	82.2
6-I	Addition	47.5	62.0	42.9
9-II	Fractions	90.8	85.3	53.6
9-IV	Fractions	44.1	37.6	18.6
10-IV	Measurement	41.4	37.6	17.8
11-III	Multiplication	83.8	82.9	64.8
13-III	Subtraction	25.6	51.4	21.0
14-II	Numeration	78.9	78.9	51.9
16-III	Subtraction	80.0	85.7	76.2
17-I	Subtraction	60.7	76.4	49.0
17-III	Subtraction	72.7	81.9	59.1
18-IV	Measurement	28.8	30.8	41.7
20-III	Division	80.0	83.0	45.8
21-III	Division	62.4	75.2	40.0
21-IV	Division	66.7	84.2	57.9
27-II	Fractions	50.4	65.4	15.7
29-I	Fractions	49.2	83.0	26.2
29-III	Fractions	55.6	80.0	20.6
	Total	63.8	73.2	49.2

APPENDIX B: MASTER CURRICULUM PLAN FOR THIRD GRADE

The following two pages display the master curriculum plan for third grade prepared before the beginning of the school year. The strand abbreviations on the left are defined in Table 8 in the text. The table entries are the exercise class identifiers. This report does not document in full the third-grade curriculum; that documentation will be the subject of a separate publication. An example of exercise class definitions is given for the horizontal subtraction strand in Table 9 of the text, which shows the definitions (as well as the identifiers) for the eight exercise classes of that strand.

The master plan is displayed here so that the reader can get a sense of the way the curriculum for the year is laid out, without concern for the details.

Original Master Curriculum Plan for 1977 Third Grade

Strand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NC	1,2	3,10	4		8	6	5	7	9							
NE	1	2	3,9	10	4	5,11	6	7	8							
NO																
NR																
NS														1		2
NF	1	3,2	4	5	6											
ND					1	3					2	4	5			
CE							1,2		3	4	5					
CF										1	3	4	5		6	
CD																
AO	1	2	5	4					3					6		
AH				1	2				3	4	5					
AV	1	2	3	4	10	12	7	8,5	9	6,11	13	16	17	18	14	15
AF														1	2	
SO	1	2	3	4							5					
SH				1	2								3			
SV	1	2	3	4		5	6	8	7	9		20	21,10	[illegible],11	12	15,13
SF															1	
GE				1	2											
MO						1						2	3	4		5
MH										1	2				3	
MV							1	2	3			4			11	
DO						1	2	3			4			5		
DV										1		2	3		4	5

17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

1 2 3 5 4 6

3 4 7 5 8 6 9 10

6 7 8 9

8 2 7

1 2 3 4 5 6 7 8 9

7

22,19 20 21 23 24 25 26 27

3 4 5 6 7

6 7 8 9 10

4 5 6 7 8

27,16 14 23 17 24 18 19 29 25 26 28 30 31

2 3 4 5 6

4 3 5

6 7

4

5,6 7 8 9,12 10 13 14 15 16

6 7 8 9 10

6 7 8 9 10 11 12

APPENDIX C: COMMENTS ON THIRD-GRADE PRETEST IN RELATION TO THIRD-GRADE CURRICULUM

NC Numeration, counting

The children can count quite well, at least up to 20, which is the most important for work in addition and subtraction.

NE Numerals, integers

The children read two- and three-digit numerals well, although there is some difficulty with a0b. About 88% of the children can read four-digit numerals that have no zeros. There is no reason three- and four-digit numerals should not be used immediately in addition and subtraction exercises, although the numerals with zeros should be retaught. There is more difficulty in writing three- and four-digit numerals, especially four-digit numerals; so exercises with these numerals should not be given by dictation until the children have more practice with numerals themselves.

NO ordinals

The children have the idea of ordinals but their ability beyond about 4th is quite low. They probably need practice reciting the ordinals in order and reading and writing the numerals so that they learn the connection between the ordinals and the cardinals.

NR Roman numerals

No test results.

NS Sequences

The children do poorly on successors of two- and three-digit numbers. They need more practice.

NF Fractions and mixed numbers

There were no test items on mixed numbers. On fractions the scores were in the 70's for recognizing halves and quarters, but much lower for thirds, fifths, and tenths. The fraction concept needs to be developed carefully. About 30% of the children do not know that the parts must be equal, and an even number do not know how many parts are associated with the words "thirds" and "tenths".

ND Decimal numbers

No test results.

CE Comparison, integers

Although most children know the meaning of the word "greater" they have little skill in determining the greatest of three numbers. A lot of practice is needed.

CF Comparison, fractions and mixed numbers

No test results.

CD Comparison, decimal numbers

No test results.

AO Oral addition

The children are quite good with sums such as 7+5. About 80% of the children must know how to count on since they can do exercises like 48+4 and 33+2. We need not waste much time with the basic facts. Counting on should be taught as a new subject but it can be done quite rapidly.

AH Horizontal addition

The children do noticeably worse in horizontal addition than in oral or vertical. It should be a simple matter to teach the horizontal form however so there is no cause for concern.

AV Vertical addition

Performance in vertical addition without carrying is not nearly high enough. There is undue difficulty with implicit zeros also. Addition with carrying is only slightly more difficult than without carrying, but is also too low (58%) and needs considerable practice.

AF Addition of fractions and mixed numbers

Fewer than one-quarter of the students can add homogeneous fractions; the instruction should start from the beginning. There are no results on mixed numbers.

SO Oral subtraction

Oral subtraction skills are considerably lower than oral addition skills. Only about 70% of the students know the greater facts (16-8, 11-4, etc.); these need to be drilled intensively.

SH Horizontal subtraction

Subtraction, like addition, has lower results in the horizontal form than in other forms. To teach the form is a simple matter. It may be wise to give lots of practice in the greater facts in horizontal form, as a change from oral drill on the same facts.

SV Vertical subtraction

The results in vertical subtraction are deplorably low, even without borrowing. With borrowing they are unspeakable. In subtraction as well as in addition there is some difficulty with implicit zeros.

SF Subtraction of fractions and mixed numbers

Performance in subtraction is worse than in addition; this skill is essentially non-existent.

MO Oral multiplication

Nearly 80% of the children know simple facts such as 2x3, 3x5, and 4x2, although it is not known whether this is due to memorization or not. The concept of multiplication should be reviewed in case there is a problem.

MH Horizontal multiplication

No test results.

MV Vertical multiplication

Using one-digit multipliers with no carrying the children do as well as in addition without carrying. Carrying is a bit more difficult and needs to be re-taught.

DO Oral division

About 50% of the children can do simple division facts without remainders (6:2, 8:4). The division concept should be re-taught.

DH Horizontal division

No test results.

DV Vertical division

The test items were all basic facts without remainders and the children seemed to do as well as or better than in oral exercises. Still the results (57%) are not high and indicate that the division concept needs to be re-taught.

OM Mixed operations

No test results.

PA, PS, PM, PD Problems in addition, subtraction, multiplication, and division

All results are a bit low. The children need more practice with problems. The results for printed problems are nearly as high as for oral problems indicating that there will be little reading difficulty in third grade.

ML Measurement, length

There were two test items on the relative sizes of meters, decimeters, and centimeters. The children's scores (29%) indicate that they know very little about this.

MC Measurement, capacity

No test results.

MP Measurement, weight

The one test item was on the relationship between grams and kilograms. The result was 0%.

MT Measurement, time

The children cannot tell time by a clock, only half of them know how many days are in a week, but 86% know that a year is longer than either a month or day. In a word, they know nothing.

MD Measurement, money

There were 5 items on finding the value of a group of coins, with average score of 54%. This subject needs more attention.

GE Geometry

85% of the children understand "parallel" and 57% of them understand "angle". There were no items on area.

Third Grade Pretest 1976

Oral component of the item		Written component		Percent correct	Mean
NC Numeration, counting					
1. Write the number that comes after this one.	I	349 ____	51.43	70.3	
	II	71 ____		75.00	
	III	682 ____		65.08	
	IV	39 ____		81.55	
	V	306 ____		78.43	
2. Count the beans and write the number on the line.	I	25 beans		84.76	89.4
	II	32 beans		87.50	
	III	8 beans		98.41	
	IV	17 beans		96.12	
	V	40 beans		80.38	
NE Numerals, integers					
4A Circle 7,359.		3759 9537 7359 7539		87.96	93.6
4B Circle 690.		69 690 960 96		97.30	
4C Circle 706.		706 760 607 76		86.90	
4D Circle 74.		40 74 47 70		99.21	
4E Circle 241		142 421 251 241		96.61	
5A Write 237				39.81	83.5
5B Write 2,989				56.76	
5C Write 608				92.86	
5D Write 71				96.06	
5E Write 830				82.20	
CE More and less					
3. Circle the largest number.	I	132 97 79		91.43	60.4
	II	923 479 150		58.93	
	III	59 73 75		78.57	
	IV	2,341 1,694 989		33.01	
	V	34 401 149		40.20	
NO Ordinals					
6A Circle the 8th soldier.		12 soldiers in a line		51.85	70.2
6B Circle the 2nd soldier.		12 soldiers in a line		95.50	
6C Circle the 4th soldier.		12 soldiers in a line		84.52	
6D Circle the 10th soldier.		12 soldiers in a line		39.37	
6E Circle the 6th soldier.		12 soldiers in a line		79.66	

(Third grade pretest 1976, continued)

Oral component of the item	Written component	Percent correct	Mean
NF Fractions			
8A Circle the figure divided in halves.	4 choices	72.22	57.0
8B Circle the figure divided in fourths.	4 choices	79.28	
8C Circle the figure divided in fifths.	4 choices	53.57	
8D Circle the figure divided in tenths.	4 choices	61.42	
8E Circle the figure divided in thirds.	4 choices	18.64	
AO Oral addition			
12A How much is 800 plus 25?		50.00	79.7
12B How much is 40 plus 50?		87.39	
12C How much is 7 plus 5?		94.05	
12D How much is 48 plus 4?		79.53	
12E How much is 33 plus 2?		87.29	
AV Vertical addition			
7. Complete this exercise.	I 41 +842	68.57	65.8
	II 23 41 10 +24	77.68	
	III 3886 +5102	69.84	
	IV 504 +132	66.02	
	V 26 + 3	47.06	

(Third Grade Pretest 1976, continued)

Oral component of the item		Written component	Percent correct	Mean
15. Complete this exercise.	I	570 + 93	42.86	58.0
	II	64 +28	62.50	
	III	667 +204	59.52	
	IV	147 +667	57.28	
	V	39 +87	67.65	
AH Horizontal addition				
9. Complete this	I	9 + 6 = ____	81.90	66.4
	II	50 + 20 = ____	66.96	
	III	400 + 65 = ____	39.68	
	IV	73 + 6 = ____	69.90	
	V	58 + 5 = ____	73.53	
SO Oral subtraction				
14A How much is 70 minus 60?			38.89	67.5
14B How much is 16 minus 8?			68.47	
14C How much is 11 minus 4?			76.19	
14D How much is 8 minus 4?			89.76	
14E How much is 85 minus 5?			64.41	
SV Vertical subtraction				
11. Complete this exercise.	I	723 -621	59.05	54.0
	II	376 - 50	46.43	
	III	76 - 5	44.44	
	IV	66 -64	70.90	
	V	7533 -2010	49.02	

(Third grade pretest 1976, continued)

Oral component of the item		Written component		Percent correct	Mean
17. Complete this exercise.	I	546 -127		20.95	20.9
	II	82 -59		26.79	
	III	865 -497		15.87	
	IV	4734 -1917		18.45	
	V	67 - 8		22.55	
SH Horizontal subtraction					
13. Complete this exercise.	I	8 - 6 = ___	67.62	57.0	
	II	60 - 40 = ___		45.54	
	III	69 - 9 = ___	50.00		
	IV	17 - 8 = ___	54.37		
	V	13 - 5 = ___	67.65		
MO Oral multiplication					
16A How much is 2 times 3?				75.00	79.1
16C How much is 3 times 5?				75.00	
16D How much is 4 times 2?				87.40	
MV Vertical multiplication					
19. Complete this exercise.	I	2413 x 2		64.76	64.3
	II	4 x2		76.79	
	III	324 x 3		50.00	
	IV	36 x 2		54.37	
	V	32 x 3		75.49	

(Third grade pretest 1976, continued)

Oral component of the item		Written component	Percent correct	Mean
DO Oral division				
16B How much is 6 divided by 2?			50.45	48.1
16E How much is 8 divided by 4?			45.76	
DV Vertical division				
21. Complete this exercise.	I	12 : 3	40.00	56.6
	II	6 : 2	58.04	
	III	8 : 4	57.94	
	IV	9 : 3	57.28	
	V	8 : 2	69.61	
AF Addition of fractions				
23. Complete this exercise.	II	2/10 + 5/10 = ____	21.43	22.8
	III	1/3 + 1/3 = ____	20.63	
	IV	2/5 + 1/5 = ____	26.21	
SF Subtraction of fractions				
23. Complete this exercise.	I	2/5 - 1/5 = ____	17.14	16.4
	V	5/10 - 2/10 = ____	15.69	
PA Oral addition problems				
24D Elena ate 4 mamones and later ate 3 more. Chico ate 5 mamones. How many did they eat all together?	12	9 8 7	83.46	83.5
PS Oral subtraction problems				
24C Jose's mother made 12 biscuits and Jose ate 5. How many biscuits are left?	5	12 17 7	82.14	82.1
PM Oral multiplication problems				
24E Mrs. Lopez sold 4 chickens for 3 cordobas each. How much money did she make?	$9	$12 $3 $7	68.64	68.6

(Third grade pretest 1976, continued)

Oral component of the item		Written component	Percent correct	Mean
PD Oral division problems				
24B Mr. Sanchez's oxen are able to plough 4 fields in one day. How many fields are they able to plough in half a day?	4	1/2 2 8	54.95	55.0
PZ Oral measuring problems				
22 In this square there is money. Jose is going to buy a melon with this money. The melon he wants costs 3 cordobas. Write how many cordobas he will get back.	I	$2 and $2	76.19	68.1
	II	$10	73.21	
	III	$5	73.02	
	IV	$50	50.49	
	V	$20	67.65	
24A Roger is going to school at 8:00 and Luis is going 2 hours later. At what time is Luis going?	6:00	10:00 8:00 12:00	62.04	62.0
PI Written problems				
25	I	Juan has 5 mangos. He eats 2. How many mangos are left? 3 10 7	86.67	70.1
	II	Eva has 3 toys. Manolo has 3 more. How many toys are there in all? 6 9 3	78.57	
	III	Dora has 4 dahlias and 2 roses. How many flowers does she have? 2 6 8	83.33	

	Oral component of the item		Written component	Percent correct	Mean
		IV	Maria has 6 carmels. Pedro has 5. Maria has more, how many more? 11 3 1	21.36	
		V	Nina bought 6 oranges. Her mother gave her 1 more. How many oranges does Nina have now? 6 7 5	80.39	
MD	Money				
10.	Write the value of this group of money.	I	50c + 50c	63.81	53.8
		II	5c + 50c	43.75	
		III	25c + 10c + 5c	48.41	
		IV	10c + 50c	63.11	
		V	25c + 10c + 25c	50.00	
MT	Measuring time				
18A	Write the time shown on the clock.	4:00		41.67	42.4
18B	Write the time shown on the clock.	2.30		7.21	
18C	Write the time shown on the clock.	8.15		23.81	
18D	How many days are in a week?	1 week = ____ days		52.76	
18E	Which is the largest?	month day year		86.44	
ML	Measuring length				
20D	Which is the largest?	decimeter centimeter meter		39.37	28.6
20E	How many centimeters are in a meter?	1 meter = ____ centimeters		17.80	
MP	Measuring weight				
20A	How many grams are in a kilogram?	1 kilogram = ____ grams		0.00	0.00

(Third grade pretest 1976, continued)

	Oral component of the item	Written component	Percent correct	Mean
GE	Geometry			
20B	Circle the parallel lines.		85.59	71.4
20C	Circle the angle.		57.14	